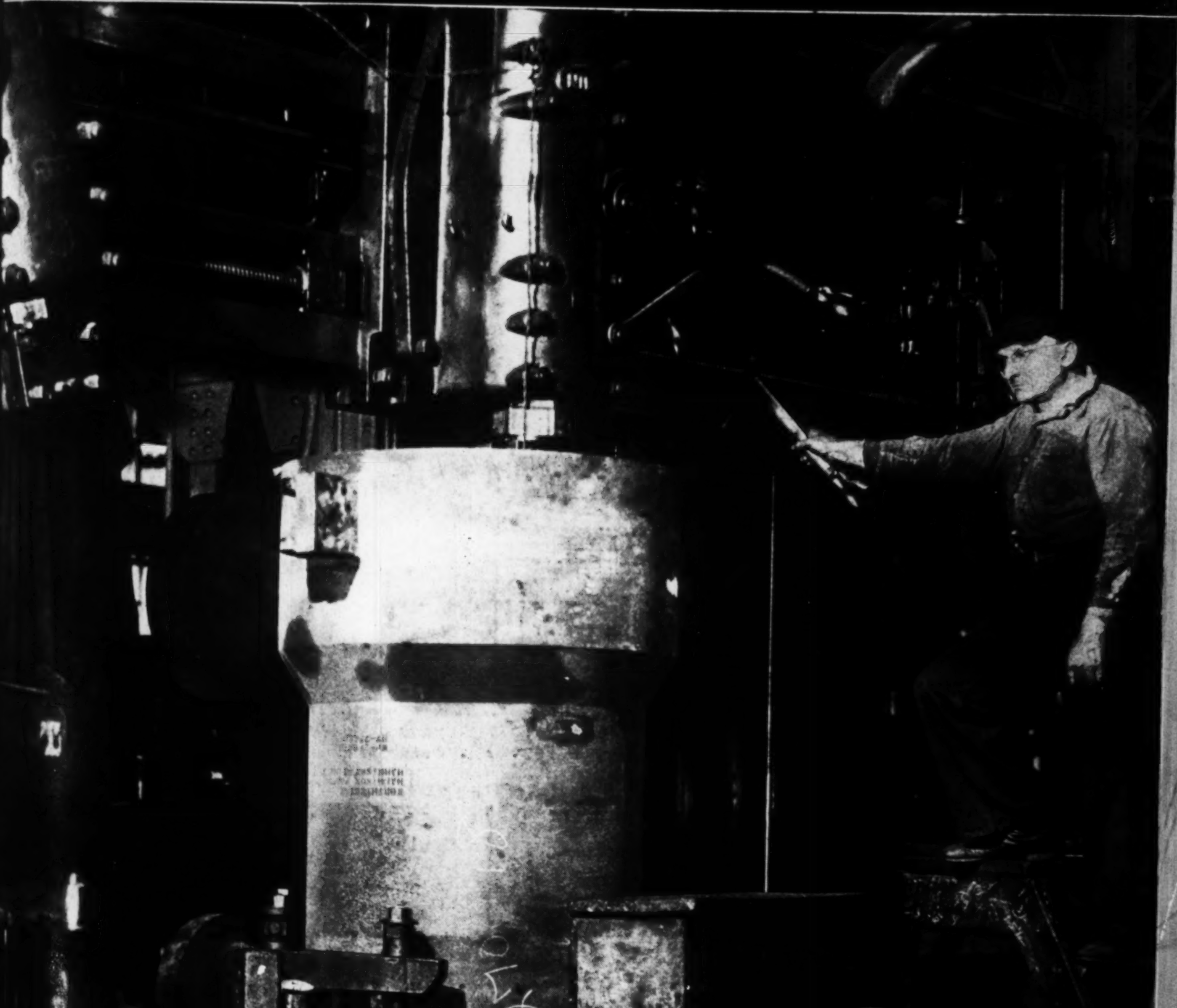
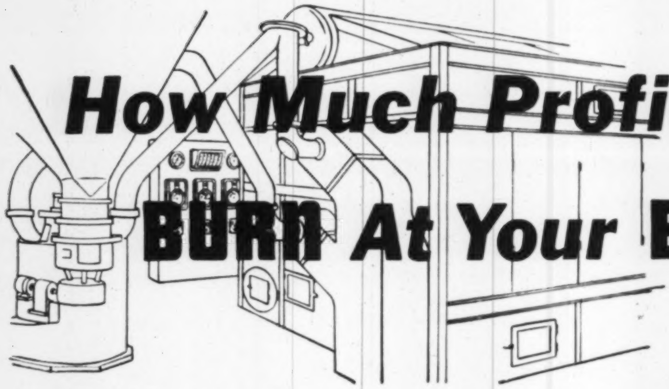
MECHANICAL ENGINEERING



OCTOBER 1947



How Much Profit Do You BURN At Your BOILER?

You Are Invited

There is a quick easy way to convince yourself that co-ordinated boiler control pays dividends in fuel saved. Ask a Bailey engineer to arrange a visit to a nearby Bailey installation. We invite your inspection.

$ Fuel dollars wasted at the boiler cut your profits. If you are seeking ways to trim costs you may find your boiler room is the place to begin. Make certain you are getting co-ordinated boiler control. This way you can be sure you are getting maximum returns from your fuel dollars.

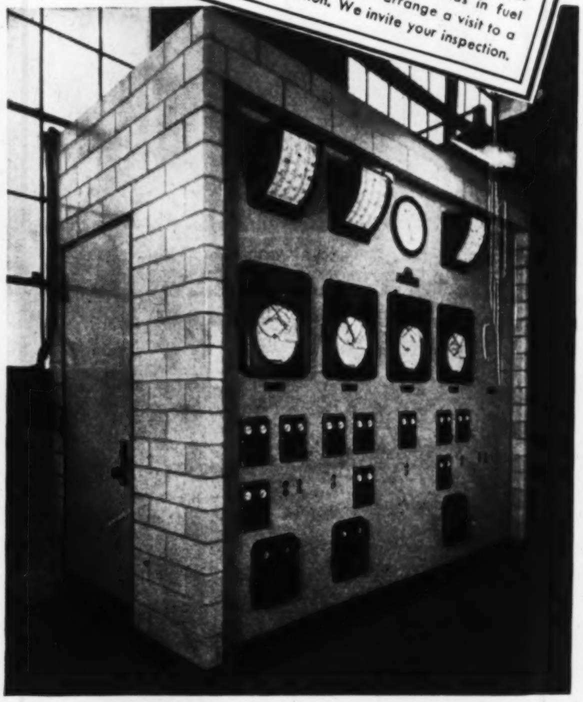
The Bailey co-ordinated boiler control system prevents wasted fuel. It increases safety of operation, improves continuity of service and reduces maintenance costs. Combustion, feed water, steam temperature, heater levels, pump speed, and all other factors are co-ordinated to deliver maximum power at minimum cost.

The Bailey co-ordinated boiler control system pays its way in fuel saved because every system is engineered to the specific conditions under which it must operate. Like your power plant, it fits the job. To find out how Bailey controls can improve your boiler performance, we suggest that you—

Call This Man

He is a Bailey engineer. Back of him are years of experience in engineering control systems for fuel burning equipment of all types. He will work directly with you and your engineers in the design and application of the meters and controls required by your installation.

This engineering service is yours for the asking—available in more than 30 industrial areas throughout the United States and Canada.



This installation of Bailey Boiler Control on three boilers fired by underfeed stokers insures fuel economy, safety of operation, and continuity of service.

BAILEY METER COMPANY

Controls

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

ENGINEERING
LIBRARY

VOLUME 69 NUMBER 10

Contents for October, 1947

THE COVER . . . . . *Boring a Large Forging. Photograph by A. Devaney, Inc., New York, N. Y.*
DEVELOPMENTS IN HIGH-SPEED AIRCRAFT . . . . *E. H. Heinemann* 805
RESEARCH AIRCRAFT . . . . *P. B. Klein* 813
ELIMINATION OF WASTE PRODUCTS OF HIGH MOISTURE CONTENT IN A GAS-TURBINE SYSTEM . . . . *J. H. Potter* 820
TRENDS IN SOLID-FUEL RESEARCH . . . . *H. J. Rose* 823
AN AIRCRAFT GAS TURBINE FOR PROPELLER DRIVE . . *Alan Howard and C. J. Walker* 827
MANAGEMENT'S CONTRIBUTION TO A BETTER STANDARD OF LIVING . . *W. L. Batt* 836
CENTENARY OF THE BRITISH INSTITUTION OF MECHANICAL ENGINEERS . *R. H. Parsons* 841
THE GROWTH OF INDUSTRIAL STATISTICS . . . . *L. C. Young* 843

EDITORIAL 803
BRIEFING THE RECORD 845
COMMENTS ON PAPERS 865
A.S.M.E. BOILER CODE 868
REVIEWS OF BOOKS 869
A.S.M.E. NEWS 873
CONTENTS OF A.S.M.E. TRANSACTIONS . . 888

INDEX TO ADVERTISING PAGES . . . 126

OFFICERS OF THE SOCIETY:

EUGENE W. O'BRIEN, *President*
K. W. JAPPE, *Treasurer* C. E. DAVIES, *Secretary*

PUBLICATION STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*
K. W. CLENDINNING, *Managing Editor*

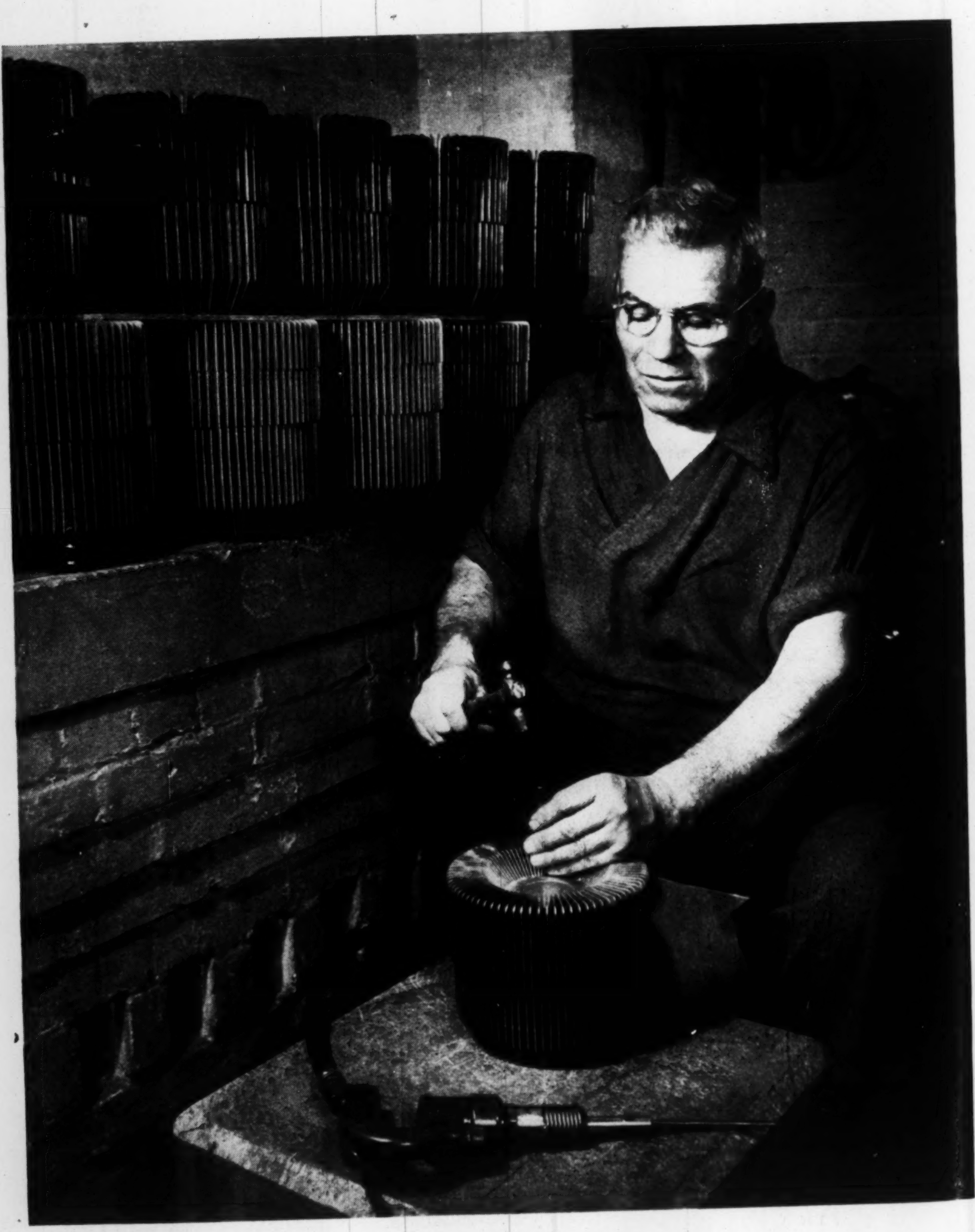
PUBLICATIONS COMMITTEE:

L. N. ROWLEY, JR., *Chairman*
H. L. DRYDEN R. B. SMITH
J. M. JURAN JOHN HAYDOCK

ADVISORY MEMBERS OF THE COMMITTEE ON PUBLICATIONS:

N. C. EBAUGH, GAINESVILLE, FLA. HUNTER R. HUGHES, JR., ATLANTA, GA.
Junior Members:
LOUIS FELD, HARRISON, N. J. JOHN H. PRENTISS, NEW YORK, N. Y.

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York 18, N. Y. Cable address, "Dynamic," New York. Price 75 cents a copy, $6.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1947, by The American Society of Mechanical Engineers. Member of the Audit Bureau of Circulations. Reprints from this publication may be made on condition that full credit be given MECHANICAL ENGINEERING and the author, and that date of publication be stated.



Electronic Craftsman

(*Workman peens edges of stampings used in assembling radiators at plant of Amperex Electronic Corporation, Brooklyn,* N. Y.)

Volume 69
No. 10

MECHANICAL ENGINEERING

October, 1947

GEORGE A. STETSON, *Editor*

Growth of Management

THE growth of the engineer's interest in management during the last half century has been matched by the contributions he has made to it. Few members of The American Society of Mechanical Engineers would have predicted fifty years ago that management would be destined to become a prime interest of the Society and yet such is the case. For although a recent study of the registration of A.S.M.E. members in its professional divisions shows, on the basis of first choice, the Power Division to be the largest (upward of 5500), the Management Division is not far behind with 5000; and when a count is made of all choices, whether major, secondary, or incidental, it is found that the Management Division tops all others.

Even if the mechanical engineer preferred to stick to the "technical" aspects of his work he would find it impossible to do so. Integration of his own activities with those of the organization of which he is a part, the most ordinary relationships between himself and his subordinates, and the orderly and efficient prosecution of his own work involve the principles of good management. It was here that his early contributions were made—in the operation of a drafting office or a production shop. Here were devised many of the techniques that have developed into well-recognized practices. It was these contributions which made it possible to bring to the consumer the products, conceived and designed by engineers, that have accelerated an advancing standard of living. This is an achievement from which this country and most of the western world have derived the benefits. But the engineer was not alone in this achievement for contributions to it in the field of management have come from all sections of the business world. It is significant that each group has been aided and supported by the others and that there has developed and is developing a body of principles and techniques which know no national boundaries in times of peace. Without good management an industrial civilization and a high standard of living cannot be maintained.

The development of this theme will be found in the address of William L. Batt at the opening session of the Eighth International Management Congress, a major portion of which is published in this issue under the title, "Management's Contribution to a Better Standard of Living." Mr. Batt finds that in spite of differing economic conditions and national aspirations which affect any definition of the term "standard of living," this term has, wherever it is used, the common quality of constant betterment, and that "while the objectives that constitute this variable standard of living will differ from place to place, the tools which management will use will not show such differences." These are helpful and hopeful concepts.

In viewing the broad picture of the effects of management which Mr. Batt paints in the bulk of his address, the reader acquires a sense of the significance of a relatively new and rapidly developing art. As Mr. Batt shows, and as the other papers of the Congress testify, management is invading every area of our lives. No longer confined to the shop and the business enterprise, it is being applied in the home, in distribution, on the farm, and in public as well as private organizations. It affects us as workers, as consumers, as citizens, and as individuals. Its techniques may be universally applied. It is destined to continue to be a subject of major interest to engineers and the A.S.M.E.

Atomic Energy

ON Aug. 11, 1947, practically the second anniversary of the atom bombing of Hiroshima (Aug. 6, 1945), at Brookhaven, L. I., on the site of Camp Upton that had served to train soldiers for two world wars, ground was broken for the Brookhaven National Laboratory where a $10,000,000 concrete-shielded atomic pile is to be built for the study of peacetime applications of nuclear energy in the fields of medicine, physics, biology, chemistry, and engineering. To Americans who read in the *New Yorker* for Aug. 31, 1946, John Hersey's report of the horrors of Hiroshima and the effects of the blast on the victims through whom he personalized his account, the laboratory at Brookhaven is an earnest of better days to come and a symbol of atonement.

The two years between Hiroshima and Brookhaven have been crowded with interest and speculation and with the concern felt by the entire world—laymen, scientists, engineers, industrialists, governments—over the consequences, destructive and beneficial, which might arise with the development of nuclear energy. To the engineer the industrial applications have had first appeal; and The American Society of Mechanical Engineers was quick to set up a Nuclear Energy Application Committee whose principal public work so far has been the presentation of appropriate papers at Society meetings.

Because of the shortness of our memories and the highly speculative nature of atomic energy in the prefission days of nuclear physics, most readers of MECHANICAL ENGINEERING will have forgotten that they read the first paper on this subject published by A.S.M.E. in May, 1931. It was called "Atomic Power From the Engineering Standpoint" and was written by Leo G. Hall. It will suffice to quote one significant passage from that paper. Said Mr. Hall: ". . . . a picture of the atomic power plant must include a comparatively small synthesis room completely enclosed by massive walls, perhaps fifty feet thick; these walls being honeycombed by an elaborate conduit system carrying a circulating fluid to convey the heat generated within the walls to its point of application. Perhaps reasons of economy would dictate that the whole system be buried deep underground."

And again in MECHANICAL ENGINEERING for February, 1933, Dr. W. F. G. Swann, in the fifth Robert Henry Thurston lecture on the relations between engineering and science entitled "Recent Advances in Physics," concluded by saying: "And so physics is well launched upon the next great stage in its attack upon the mysteries of nature. The nucleus has withstood assault for many years, but in the experiments of Cockcroft and Walton the physicist has already tasted the blood of conquest. Bigger guns are being built for the attack, and who knows but that in time we may realize in a practically usable sense the dream of the alchemist, the transmutation of the elements, and with it the still more dramatic hope, the utilization of atomic energy in the service of mankind."

It will be noted that both these writers visualized not Hiroshima but Brookhaven.

Are Engineers Snubbed?

WHEN engineers read the programs of convocations held at universities to discuss the problems of the day they are sometimes annoyed to discover that no member of their profession is listed among the speakers. No discussion of contemporary life, they argue, is complete without reference to its engineering phases and no discussion of engineering phases is competent without engineering representation. Yet engineering subjects and engineers are conspicuously absent from many programs on which both should be represented, and many times engineering subjects are listed with nonengineering speakers. Why is this? Are engineers being snubbed?

Without examining specific cases it would be unfair to assume that there is any conscious effort on the part of program makers to neglect engineering or engineers. If neglect exists, at least some of the fault can be traced to engineers themselves and to the nature of their work. And if one were to consider the atmosphere of a university or college, excepting, naturally, engineering colleges and institutes of technology, he would probably come to the conclusion that academic and engineering thinking are miles apart. What is significant and of value to one group is likely to be misunderstood or ignored by the other.

Consider, for example, the mechanical engineer. The chances are he is employed in industry. What community of interest is there in the academic and the industrial ways of life? What points of view are there in common? How well does one group understand the other? How wide is the acquaintanceship of members of one group with those of the other? To what extent do men in academic circles look to engineers for leadership in their thinking? Is it natural that they should do so? To what extent do engineers understand the functions of the university? Is the engineer consciously or unconsciously biased in his views on public matters because of his connection with industry? Although he may be able to consider technical problems with cool objectivity, can he maintain the same attitude in his approach to questions which involve traditional social, economic, and political points of view? Are his perspective and frame of reference broad enough in these matters to save him from naive and uncritical judgments? These are annoying questions, but it would seem wise for both the engineer and the university to face them. Honest answers would be helpful to both groups.

The fault is far from lying entirely with the engineer, as the sample questions themselves suggest. For in spite of all that has been written on engineering education and the significance of engineering to modern life, it is doubtful if universities, again excepting the engineering college and the institutes of technology, have given these matters the attention they deserve.

It is not necessary to propose that universities compete with engineering colleges or institutes of technology in offering courses in engineering for undergraduate students in order to correct misundertandings that may now exist. Indeed, in some cases, this would be wasteful and undesirable. But it is important that universities should be aware of the importance of engineering and its influence on contemporary civilization. And in universities where engineering curricula are offered, closest attention should be given toward an alliance between engineering, the sciences, and all other fields of study for the further enrichment of each and the best development of all students. If it is a function of a university to prepare men and women for useful and satisfying living and service to society, engineering cannot be neglected. Nor should engineering students be treated differently from the others, whether their education is cast on vocational or professional lines. Closer integration must always be sought and this can come about only when the need for it is recognized.

The engineer cannot shirk his responsibility in this area. His work is normally in industry rather than in the university, but this does not license him to think of his own work or of his profession in a social vacuum. Too few engineers can be named who are leaders in the integration of engineering with other significant concerns of society. Few men indeed in any field are sufficiently gifted and motivated to become well-known leaders of contemporary thought outside their own technical specialties or are able to interpret the significance of their specialties to the public or even to interested groups of educated persons. When an engineer possessing such gifts does appear and makes use of them, he usually finds respectful audiences, in universities and elsewhere. But he has to be good. With a sufficient number of such men available, engineers will have no cause to imagine that they are being snubbed.

Developments in
HIGH-SPEED AIRCRAFT

By E. H. HEINEMANN

CHIEF ENGINEER, DOUGLAS AIRCRAFT COMPANY, INC., EL SEGUNDO, CALIF.

FORTY-FOUR years ago the Wright brothers made their first flight, reaching a speed of 31 mph. During this short time aviation, the youngest mode of transportation, has surpassed in speed all other forms of transportation. Unlike earth-bound and marine transportation, which appear to have settled down to a very slow rate of progress, aircraft speeds continue to increase at a relatively high rate. The future rate of increase is highly speculative. Some enthusiasts predict air travel at thousands of miles per hour in the next few years; the pessimists, of course, predict reaching a practicable limit in the near future. Both are probably incorrect; certainly some of the predictions have been based on "facts" of questionable origin.

From a purely theoretical point of view there appears to be no reason why aircraft speeds will not advance at an increasing rate in the future because of the many recent scientific advancements. From a practical and economical point of view, it appears that the tremendous costs involved in developing high-speed aircraft may limit, or at least largely influence, the rate of progress in the foreseeable future.

THE AIRPLANE PROGRESS RECORD

It is always much more interesting to speculate into the future than to face the grim realities of the present, but since the future possibilities of aviation have been so thoroughly covered by the popular writers and Buck Rogers, it is believed appropriate to confine this discussion mainly to the facts of the present and recent developments.

If, now, we review the progress of aviation and compare it with other modes of transportation, as shown in Fig. 1, we find that railroad and automobile operating speeds have been increasing at a rate of approximately 1 mile per year, whereas air-transport operating speeds have been increasing at a rate of approximately 7 miles per year. These rates refer to normal operating speeds of regularly scheduled carriers and not to record speeds. Automobile record speeds have been increasing at about the same rate as airplane record speeds during the past 20 years, but still lag behind airplanes by approximately 250 mph. Perhaps the point of greatest interest of this chart is that air travel has made the greatest progress in speed of all fields of transportation and is thus the most logical form of high-speed transportation.

AIRPLANE-SPEED DEVELOPMENT

Analyzing the trend of airplane speeds further, it can be seen by Fig. 2, that aircraft speed records since the Wright brothers' first flight have increased to the present mark of 616 mph which it will be recalled was established by the British "Meteor" in 1946. This progression should probably have been logarithmic rather than linear, but since it has been largely influenced by economic conditions, it happens that our progress to date has been approximately linear at the rate of 14 miles per year. It is interesting that air-transport cruising speeds have been steadily increasing at approximately one half the speed of the record-breaking airplanes, or seven miles per year.

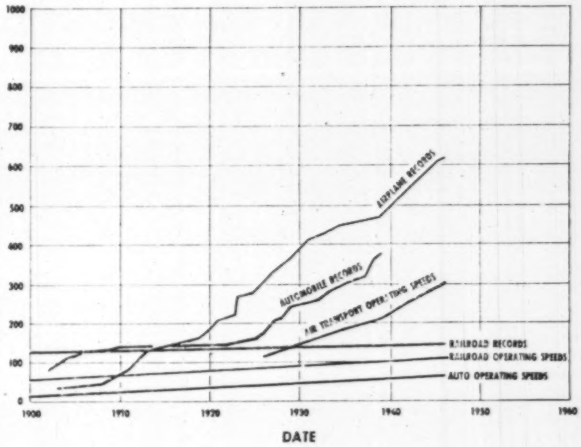


FIG. 1 TRANSPORTATION SPEEDS; OPERATING AND RECORD

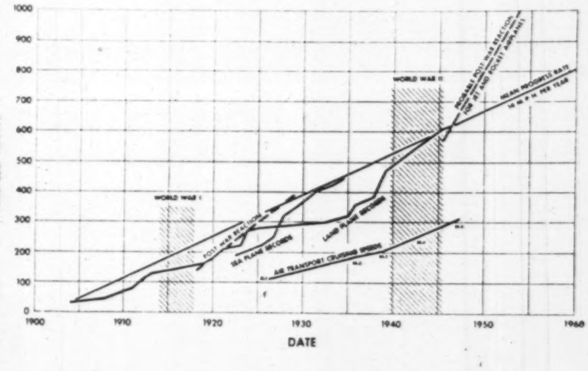


FIG. 2 AIRPLANE SPEEDS; OPERATING AND RECORD

With all the recent attempts to break the world speed record, it was thought certain that the 14 miles per year rate would be exceeded during 1946. The 1946 gain, however, was only 10 mph.

It will be observed in Fig. 2, that progress is always improved by an incentive or stimulus. For example, as a result of the research development and money spent during the first world war, there was a pronounced postwar reaction for a period of approximately 5 years. Under the impetus of the Schneider trophy there was a pronounced acceleration in seaplane speeds, causing them to surpass landplane speeds in 1927. The increase during the recent war can probably be

---

Presented at the National Meeting of the Aviation Division, Los Angeles, Calif., May 26–29, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

accounted for by the experience gained in assisting our Allies during the period just prior to the war. It is considered quite probable that a postwar reaction will take place during the next few years as a result of the great scientific advancement made during war years.

SPEED-RECORD HISTORY

Comparing the progress of aviation with other speed-record histories, Fig. 3 illustrates the progress of missiles and vehicles since the year 1800. It will be observed on this chart that the rate of progress for each new scientific development in history seems to be greater than previous developments, owing, no doubt, to the general advancement of science. An exception to this is the rocket. Rockets have been in existence since the thirteenth century, but it was not until the last few years that a rapid advancement in this field was made, and then only after vast sums of money had been made available for rocket development.

From this chart and recent news comments, one would naturally conclude that rocket travel may be the next mode of high-speed travel; and little wonder. The development of the German V-2 rocket has pointed out to the world the great potentialities of rocket flight. The development of rockets as uninhabited missiles capable of being fired to any point on the face of the earth appears to be within the realm of possibility in the relatively near future. The greatest unsolved problems in

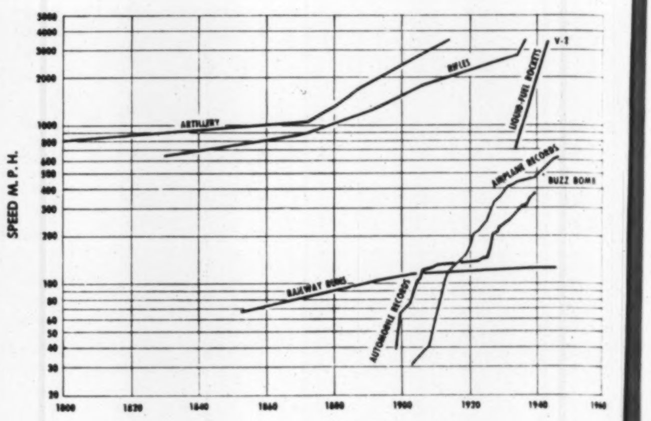


FIG. 3 SPEED-RECORD HISTORY

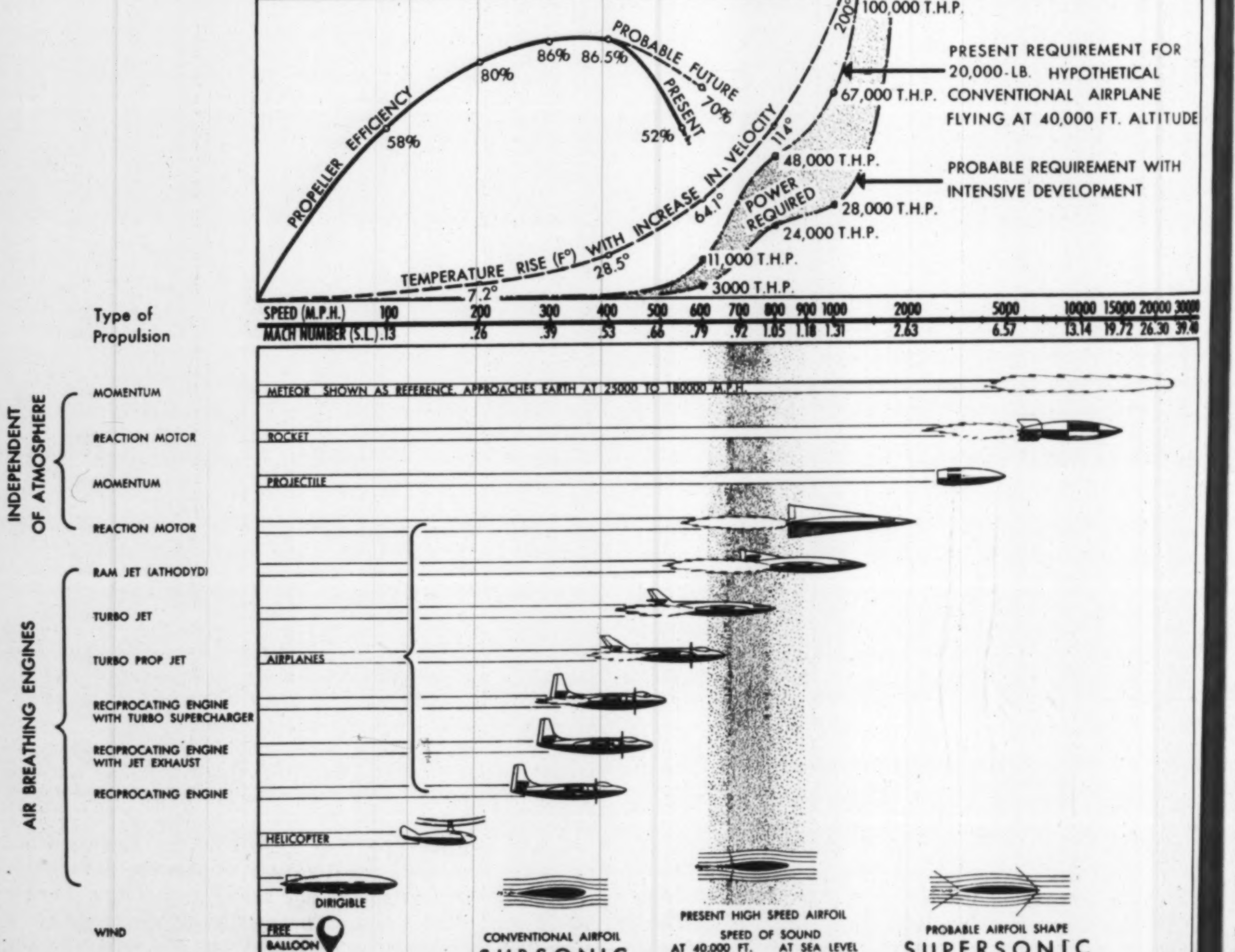


FIG. 4 FLIGHT AND PROPULSION SPECTRUM
(Past and probable future as visulized in the year 1947.)

this field are generally considered to be those of obtaining satisfactory guidance and control. Since rockets operate most efficiently above the earth's atmosphere, the problem of using them for human transportation is somewhat more complicated due to the necessity of re-entering the atmosphere and landing safely. Various methods of slowing down a rocket, without its becoming overheated while re-entering the atmosphere at several thousand miles per hour, appear possible. However, no practicable method has yet been developed. Everyday rocket travel therefore appears to be in the rather distant future.

A TYPE FOR EACH PURPOSE

The many recent developments in aircraft and space craft are shown in Fig. 4. This chart was prepared in order to facilitate the thinking and understanding of this subject, and to illustrate that there is a most suitable-type craft and method of propulsion for each purpose.

At the top of the chart are curves illustrating some of the more significant characteristics of high-speed flight. These curves pertain to air-borne machines and do not apply to rocket or space devices operating beyond the earth's atmosphere.

The first of these illustrates that with present knowledge propeller-driven airplanes are limited to speeds of approximately 600 mph.

The second curve demonstrates that a vehicle flying through the atmosphere at increasing speeds for sustained periods of time will experience an increase in temperature from friction or aerodynamic heating. This was considered, until the last few years, as unimportant and often was overlooked. Although the temperature will increase as the square of the speed, the chart does not show it beyond 200 F or 1000 mph.

The third curve shows the abrupt increase in power required at speeds above 500 mph with present-type aircraft.

The dotted line indicates a probable power requirement which may be realized in the not too distant future, as the result of intensive aerodynamic development.

It is interesting that a present-day hypothetical 20,000-lb airplane of conventional design, flying at a 40,000-ft altitude would require approximately 11,000 thrust hp to fly at a speed of 600 mph. If it should be desired to increase the speed of the same airplane to 1000 mph, it would be necessary to increase the power sixfold to 67,000 thrust hp. It is doubtful that any present-day airplane could withstand the forces imposed at 1000 mph even if this power were available.

The speed and corresponding Mach numbers are shown in a modified logarithmic scale for convenience in the illustrations on the chart.

The vertical band illustrates a speed range between approximately 600 and 900 mph, generally referred to as the "sonic barrier."

The airplane illustrations on the chart indicate the most probable operating ranges for each of the various types of craft and methods of propulsion.

Unfortunately, no simple method of introducing altitude effects into this chart has been found. It must be borne in mind that the reciprocating engine, propeller-turbine engines, turbojet engines, and ram-jet engines are all air-breathing, and therefore are confined to the lower atmosphere. Rockets, carrying their own oxidizers, are independent of the atmosphere, and therefore operate best in space.

The reader has probably been wondering why the words sonic barrier have been in such common use and are illustrated so prominently. Perhaps one of the best answers to this question is that, in spite of all the attempts which have been made, there is no living person who has ever been able to reach the speed of sound. The only self-propelled machines which have exceeded the speed of sound are uninhabited missiles or rockets. This situation has naturally been a strong challenge, not only to our abilities, but our imagination, and has resulted in the logical expression, sonic barrier.

SPEED VERSUS SOUND

Discussions of present-day flying require frequent reference to the speed of sound and the Mach number. The Mach number is the ratio of a given speed to the speed of sound, a Mach number of 1 being the speed of sound. These references are very important to present-day flight studies, as compressibility effects, which are perhaps among our greatest problems, bear a direct relationship to the speed of sound.

Fig. 5 shows that the speed of sound varies directly with altitude between 761 mph at sea level and 663 mph at 35,000 ft. It is constant above that point to 100,000 ft. For example, a compressibility characteristic that may occur at a Mach number of 0.9, or approximately 685 mph at sea level, will also occur in very much the same way at a Mach number of 0.9 at a 35,000-ft altitude, but at that altitude at a true speed of only approximately 595 mph.

Contrary to common belief, the speed of sound is proportional to temperature variations only, not density.

TRANSONIC COMPRESSIBILITY PROBLEMS

Perhaps one of the greatest problems in going through the so-called sonic speed barrier is learning to control the inconsistent air forces encountered in that speed range. Air flow in the subsonic range below about $^3/_4$ of the speed of sound is relatively consistent. At about that speed, however, local veloc-

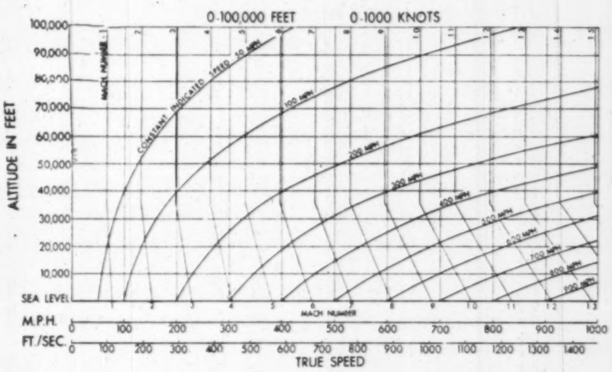


FIG. 5 RELATIONSHIP BETWEEN INDICATED SPEED, TRUE SPEED, AND MACH NUMBER

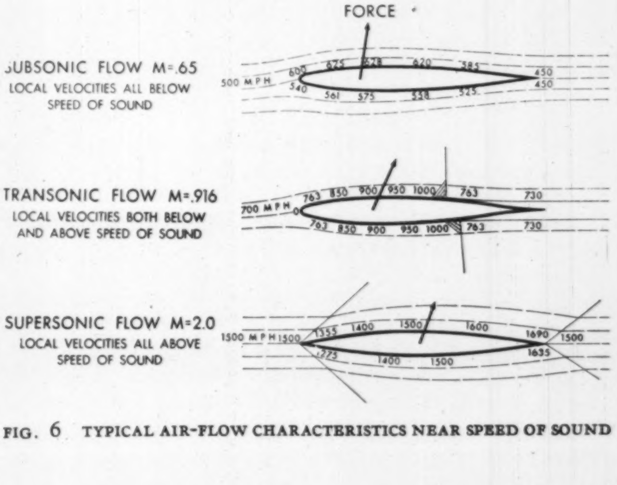


FIG. 6 TYPICAL AIR-FLOW CHARACTERISTICS NEAR SPEED OF SOUND

ities over highly contoured surfaces reach the speed of sound resulting in compressibility effects or shock waves.

Fig. 6 illustrates, for example, that when a normal subsonic wing travels at 500 mph, local velocities are accelerated to the neighborhood of 600 mph or more depending upon the contour of the airfoil.

The same airfoil, however, when traveling at 700 mph, will have local velocities in the neighborhood of 1000 mph, well above the speed of sound. This results in compressibility effects and shock waves, as diagrammatically illustrated.

The typical supersonic airfoil shown at a Mach number of 2, has a definite shock-wave pattern, but is believed much more stable than the transonic case.

To reduce the adverse effects of compressibility and shock waves with airplanes of recent design, great effort has been made to keep local velocities as low as possible. This has necessitated decreasing both thickness and camber of wings. Where wing sections of 18 per cent thickness (ratio of wing thickness to wing chord) were quite common a few years ago, many high-speed airplanes now have wings of only 8 and 10 per cent thickness, and some designs under consideration as thin as 4 to 6 per cent. This trend imposes many new structural and aerodynamic problems and will continue to challenge the ingenuity of designers for many years to come.

Supersonic airfoils of the future will probably have pointed leading edges similar to the typical supersonic airfoil shown. The greatest objection to this type airfoil is the low lift coefficient which makes it, at present, impracticable to meet the low-speed stability control and landing requirements for human-carrying airplanes. The development of extensible rounded leading edges may offer a solution to this problem but, as yet, there has been no satisfactory full-scale application.

The two most likely methods of achieving supersonic flight appear to be to increase the speed of subsonic-type airfoils by controlling the compressibility effects, and the development of the supersonic airfoils to permit their efficient use at low speeds. Both methods are being investigated and they show promise.

This chart also contains a simplified description of subsonic, transonic, and supersonic speeds. The subsonic extends from zero to approximately $^3/_4$ of the speed of sound and is defined as a speed range where local velocities over an airplane are all less than the speed of sound. The transonic region is shown between approximately $^3/_4$ the speed of sound and 1.2 times the speed of sound, and is defined as a region where local velocities are both above and below the speed of sound. It is this combination of speeds which causes transonic-stability difficulties. The supersonic region is simply defined as the region where all velocities exceed the speed of sound. Although these conditions are generally believed to be relatively steady, there is still very little known about them.

POWER REQUIREMENTS

In addition to the adverse effects of compressibility on stability and control, compressibility greatly increases the power requirements in the transonic range, as shown in Fig. 7. Here again, to illustrate the point, a typical 20,000-lb hypothetical airplane of modern design was chosen, but the requirements in this case are based on sea-level operation.

The lower curve under the shaded area illustrates the power required for incompressible flow. In other words, without compressibility, it would be possible to reach 1000 mph at sea level with approximately 12,000 hp. Due to compressibility effects, the actual power required to fly 1000 mph at sea level is a little over 80,000 hp. The shaded area shows the power increase resulting from compressibility.

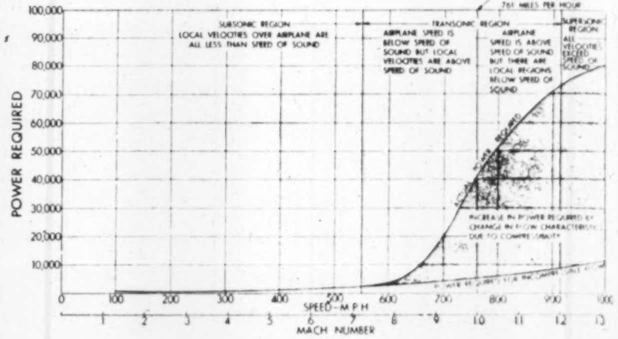


FIG. 7 POWER REQUIRED VERSUS SPEED FOR A TYPICAL AIRPLANE AT SEA LEVEL

(Hypothetical airplane of modern design 20,000 lb gross weight.)

ATMOSPHERIC CONSIDERATIONS

Knowledge of the upper atmosphere has taken on a new and important significance. With the operating altitude of airplanes increasing to the stratosphere for greater reduction in aerodynamic drag, and rockets operating at their greatest efficiency outside of the atmosphere, it has recently become necessary to increase our general knowledge on the subject. To this end, various government-sponsored high-altitude exploratory projects are understood to be in progress. Fig. 8 illustrates the characteristics of the atmosphere in accordance with the present somewhat arbitrary but best available knowledge.

As can be seen on this chart, the absolute air pressure drops off from 14.7 at sea level to 0.16 psi at 100,000 ft, thus indicating that aircraft can generally be considered as being confined to altitudes well under 100,000 ft. In this connection, it is interesting that the world's airplane altitude record of 56,176 ft established by Colonel Mario Pezzi of Italy in 1938, and the occupied-balloon altitude record of 72,395 ft established by Anderson and Stevens in 1935, still stand. There has been surprisingly little activity in this field in recent years.

The standard air-temperature variation with altitude for our latitudes is shown as a straight line from 59 F at sea level to —65 F at 35,000 ft, and constant above that point to 100,000 ft. The true average probably follows more nearly the dotted line. Above 100,000 ft it is believed to rise to approximately 300 F at 200,000 ft. Although it is apparent from noctilucent clouds at altitudes of approximately 250,000 ft that temperatures are below freezing, the variations of temperature between day and night and between various sources of data are such that it could not be shown simply on this chart.

The speed-of-sound curve parallels the temperature curve, since as previously mentioned, it is influenced only by temperature.

The effects of higher altitudes on human beings and aircraft are of considerable interest. For the average inactive human being, supplementary oxygen is required between 15,000 and 20,000 ft, if not lower. At 21,000 ft there is insufficient oxygen to support the combustion of a candle flame. At 32,000 ft, where the temperature is —65 F, gasoline boils if unpressurized. At 33,000 ft pure oxygen must be breathed in order to supply a human body with oxygen equivalent to the amount normally breathed at sea level. At 63,000 ft and body temperature of 98.6 F, blood will boil without pressurization. At approximately 250,000 ft sound waves are no longer propagated due to the increased distance between the molecules of the air. These points of interest clearly indicate the need for cabin pressurization and air conditioning.

The development of the rocket has supplied the scientists

PERCENTAGE COMPOSITION OF EARTH'S ATMOSPHERE BY VOLUME

Nitrogen	77.77
Oxygen	20.86
Water Vapor	.41
Argon	.93
Carbon Dioxide	.03
Hydrogen	.0005

Composition practically constant with altitude up to 30 miles, except for water vapor.

CHARACTERISTICS OF UPPER ATMOSPHERE UNDER MOST PROBABLE CONDITIONS

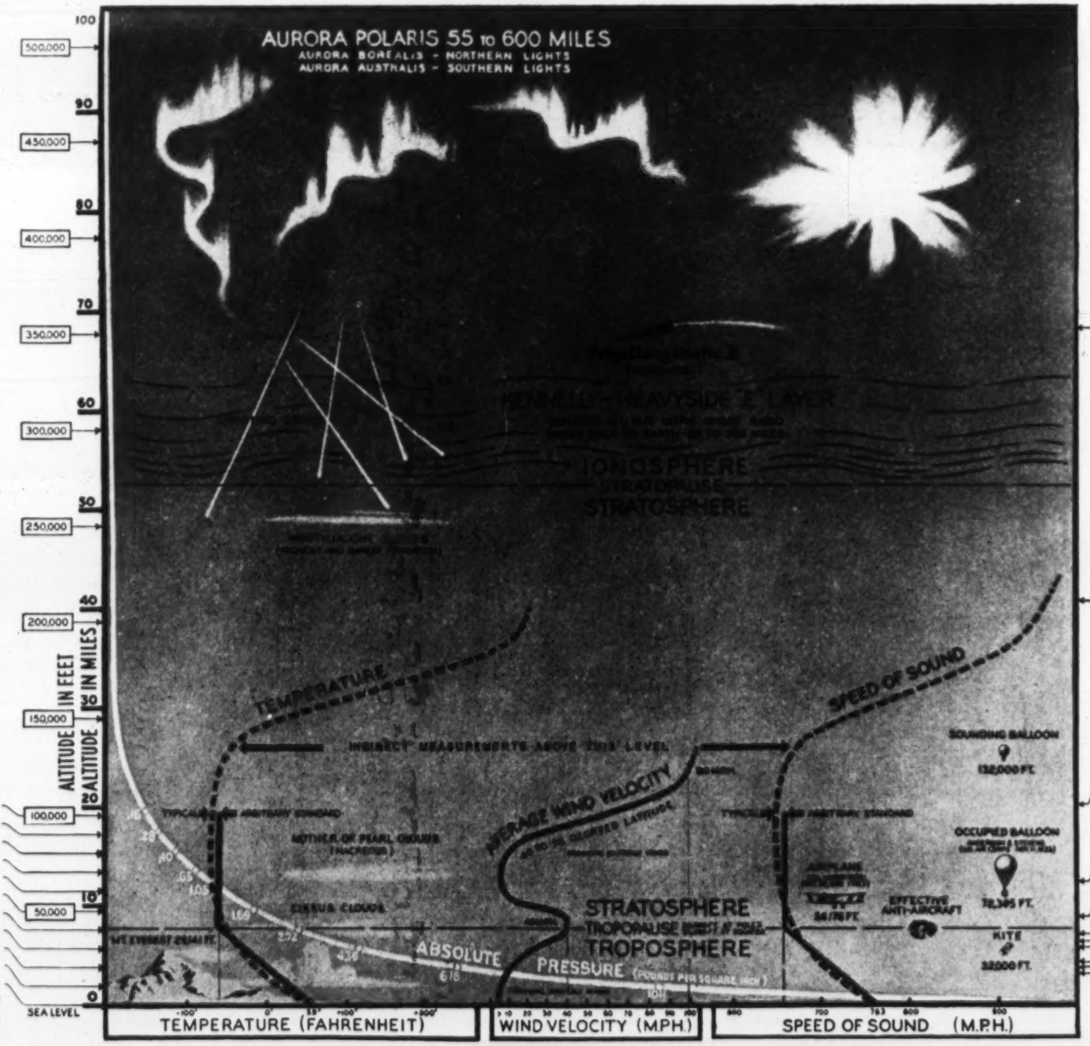
Altitude in Feet	Altitude in Miles	Weight of Air in Lbs. per Cubic Foot	Mean Free Path in Inches	Molecules Per Cubic Inch
500,000	94.6		370.	43. x 10^{11}
450,000	85.2		65.	25. x 10^{12}
400,000	75.8		12.	15. x 10^{13}
350,000	66.3	0.2 x 10^{-8}	1.9	84. x 10^{13}
300,000	56.8	2.6 x 10^{-7}	0.3	48. x 10^{14}
250,000	47.4	*2.9 x 10^{-6}	5.8 x 10^{-2}	27. x 10^{15}
200,000	37.9	1.6 x 10^{-5}	1.0 x 10^{-2}	16. x 10^{16}
150,000	28.4	9.5 x 10^{-5}	1.7 x 10^{-3}	96. x 10^{16}
100,000	18.9	.00107	2.7 x 10^{-4}	62. x 10^{17}
50,000	9.5	.0116	3.6 x 10^{-5}	47. x 10^{18}
0	0.0	.0765	†3.5 x 10^{-6}	‡44. x 10^{19}

---

* 2.9 x 10^{-6} = 2.9 pounds per million cubic feet.
† 3.5 x 10^{-6} = 3½ millionths of an inch between molecular collisions.
‡ 44 x 10^{19} = 440,000,000,000,000,000,000 molecules per cubic inch.

ARBITRARY STANDARD ATMOSPHERE FOR 45 DEGREES LATITUDE

Altitude in Feet	Speed of Sound (M.P.H.)	Ratio of Altitude to Sea Level Densities	Pressure (Lbs. per Square Inch)	Temperature F°	Temperature C°	Weight of Air (Lbs. Per Cubic Foot)
100,000	664	.014	.16	—67°	—55°	.0011
90,000	664	.023	.28	—67°	—55°	.0017
80,000	664	.036	.40	—67°	—55°	.0028
70,000	664	.058	.65	—67°	—55°	.0044
60,000	664	.094	1.05	—67°	—55°	.0072
50,000	664	.152	1.69	—67°	—55°	.0116
40,000	664	.245	2.72	—67°	—55°	.0187
30,000	680	.374	4.36	—48°	—44°	.0286
20,000	708	.533	6.76	—12°	—25°	.0408
10,000	736	.738	10.11	+23°	— 5°	.0565
0	763	1.000	14.70	+59°	+15°	.0765


AURORA POLARIS 55 TO 600 MILES
AURORA BOREALIS - NORTHERN LIGHTS
AURORA AUSTRALIS - SOUTHERN LIGHTS
KENNELLY-HEAVYSIDE "E" LAYER
IONOSPHERE
STRATOPAUSE
STRATOSPHERE
TEMPERATURE
INDIRECT MEASUREMENTS ABOVE THIS LEVEL
SPEED OF SOUND
AVERAGE WIND VELOCITY
SOUNDING BALLOON
132,000 FT.
OCCUPIED BALLOON
72,395 FT.
MOTHER OF PEARL CLOUDS
(NACREOUS)
CIRRUS CLOUDS
MT. EVEREST 29,141 FT.
STRATOSPHERE
TROPOPAUSE
TROPOSPHERE
EFFECTIVE ANTI-AIRCRAFT
AIRPLANE
KITE
32,000 FT.
ABSOLUTE
PRESSURE (POUNDS PER SQUARE INCH)
.16
.28
.40
.65
1.05
1.69
2.72
4.36
6.76
10.11
14.70
ALTITUDE IN FEET
ALTITUDE IN MILES
100
90
80
70
60
50
40
30
20
10
0
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
SEA LEVEL
TEMPERATURE (FAHRENHEIT)
-100°
0°
59°
+100°
+200°
WIND VELOCITY (MPH)
10
20
30
40
50
60
70
80
90
100
SPEED OF SOUND (M.P.H.)
600
700
763
800
900

German V2 rocket bombs attain this altitude during flight, approximately 360,000 feet. (Reported to have attained an altitude of 160 miles in experimental vertical flight.)

Sound waves not propagated above this altitude due to increased distance between molecules.

Twilight limit. First magnitude stars are visible directly overhead when sun sets. 210,000 feet.

Maximum ozone concentration (one part ozone to 100,000 parts atmosphere.) 106,000 feet.

Blood boils at body temperature, 98.6° Fahrenheit. 63,000 feet.

100 per cent oxygen needed for sustenance of life. Exact altitude depends on individual and exposure. 40,000 to 45,000 feet.

Breathing pure oxygen equivalent to breathing sea level air. 33,000 feet.

Gasoline boils at normal temperature, —65° Fahrenheit. 32,000 feet.

Sky appears purple above this point. 30,000 feet.

Candle no longer burns. 21,000 feet.

Highest community of human beings, Andes Mts., South America. 18,000 feet.

Oxygen required for sea level dwellers to live. Altitude depends on physical condition and duration of stay. 15,000 to 20,000 feet.

FIG. 8 CHARACTERISTICS OF THE EARTH'S ATMOSPHERE
(Summarized from information available in 1944.)

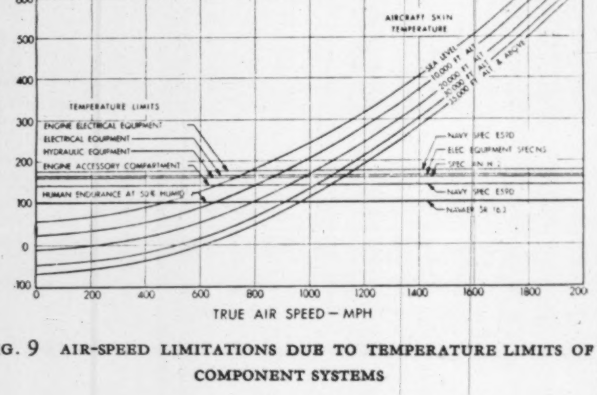


FIG. 9 AIR-SPEED LIMITATIONS DUE TO TEMPERATURE LIMITS OF COMPONENT SYSTEMS

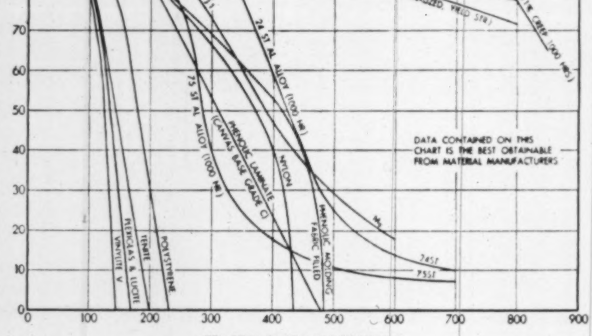


FIG. 10 EFFECT OF TEMPERATURE ON STRENGTH OF AIRCRAFT MATERIALS

with a new tool for the investigation of the upper atmosphere, and it is hoped that sounding rocket flights to the upper atmosphere will, in the near future, supply the aeronautical engineers with much more complete and reliable data than are presently available.

Here again the possibilities of rockets can be appreciated by comparing the 65-mile altitude of the German V-2, which later, in this country, reached over 100 miles, with the 10-mile altitude record of the airplane.

TEMPERATURE PROBLEMS

During the past few years, the problems of designing and testing aircraft equipment to operate at the frigid (—65 F) temperatures encountered in the upper atmosphere have, in general, been satisfactorily solved. There now appears a much more serious problem in raising the upper temperature limit of structures and equipment. Fig. 9 illustrates temperatures which may be encountered in continuous flight at speeds between zero and 2000 mph, and at altitudes from sea level to 35,000 ft due to the compressibility heat rise.

It can be seen from this chart that flight at sea level at 800 mph would result in the entire aircraft and equipment exceeding the temperature of all structural and equipment-design specifications. This does not take into account engine heat or solar radiation which usually further aggravates the problem. At 35,000 ft and above, this speed would be raised to 1150 mph because of the cooler upper atmosphere.

It is quite obvious from this chart that, at speeds much above 600 mph, it will be necessary to develop equipment capable of withstanding higher temperatures than present equipment, or provide sufficient refrigeration for vital items of equipment. Many modern airplanes are already being provided with refrigeration in order to maintain cockpit and cabin temperatures at endurable levels.

MATERIAL TEMPERATURE LIMITS

As will be recalled, Fig. 4 showed an aerodynamic temperature rise of 200 F at a speed of 1000 mph. Now let us see what would happen to an aircraft structure when traveling 1000 mph near sea level on a standard 100 F hot day. Add the 200 F temperature rise to the 100 F ambient, and it will be seen from Fig. 10, that the approximate allowable stresses of various materials are as follows: Chrome-molybdenum steel is down to about 92 per cent; 24S aluminum alloy, to 87 per cent; magnesium, to 72 per cent; phenolic moldings, to 68 per cent; nylon, to 67 per cent; phenolic laminates, to 52 per cent; 75S aluminum alloy, to 40 per cent; and the various plastic materials are down to zero.

Now, of course, if this same airplane were flying at 35,000 ft or above, where the temperature would be approximately —65 F, it would be possible to operate at 1000 mph with less than a 10 per cent strength reduction in the structural materials mentioned, with the exception of the plastic materials. Thus it can be seen that every present indication is that the 1000 mph airplane would be required to confine its full-speed operation to higher altitudes and limit its sea-level operation, particularly on hot days, to the neighborhood of 700 mph.

A TYPICAL HIGH-SPEED AIRPLANE

Perhaps the best way to illustrate the development of high-speed airplanes would be to describe some of the features of a recent transonic airplane design, the Douglas D-558 "Skystreak." This project is a research airplane built for the United States Navy in co-operation with the National Advisory Committee for Aeronautics.

This airplane was started approximately 2 years ago when it became apparent that there were not sufficient aerodynamic flight-test data available in the transonic-speed range with which to design new combat airplanes. It was impossible to obtain satisfactory test data in wind tunnels owing to the confining nature of tunnel walls which aggravate compressibility effects. These problems could be partially solved by the use of very small scale models or very large tunnels. The results of the small tunnels are always questionable, and larger tunnels would require exorbitant expenditures and years to construct. The only satisfactory solution therefore appeared to be the construction of a research airplane capable of measuring and recording automatically all the forces acting upon an airplane in flight. It was for this purpose that the Skystreak was conceived and built strictly as a research airplane, uncompromised by combat or military equipment. Its only load-carrying requirement was to carry 500 lb of automatically recording instrumentation.

Fig. 11 is an exterior view of the airplane in flight and illustrates the trend in this type airplane. A mid-wing arrangement was desired, but the space occupied by the engine necessitated the low-wing arrangement. The horizontal tail was raised as shown to keep it as far out of the wing influence as possible.

Fig. 12 is a cutaway view showing the compactness of arrangement and illustrates the architectural problems of fitting a large number of odd-shaped articles into the smallest possible aerodynamic shape.

In order to obtain the greatest energy recovery from the air supply to the engine, a nose intake was chosen which necessitated a bifurcated duct around the pilot's cockpit and considerably congested the forward compartment of the airplane.

The power plant is a General Electric TG-180 turbojet, the most powerful engine available in this country.

The gross weight of the Skystreak with 230 gal of fuel is 9750 lb. Its take-off wing loading is 65 psf, but its landing wing loading is only 56 psf. The landing wing loading is approximately the same as the Douglas A-26 bomber. It has a 25-ft span and is 35 ft long.

The uncertainties of transonic flight made it advisable to provide additional strength, approximately 60 per cent greater than required for current fighters. Due to the thinness of the wing, the Bendix Company was called upon to design special wheels and brakes, and the Goodrich Company produced a special eight-ply nylon tire with a normal inflation pressure of 190 psi.

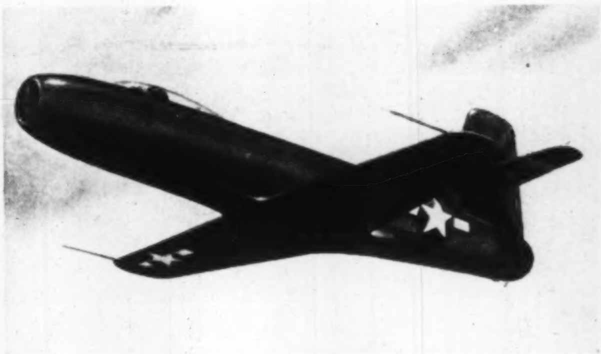


FIG. 11 DOUGLAS D-558 SKYSTREAK U. S. NAVAL HIGH-SPEED RESEARCH AIRPLANE

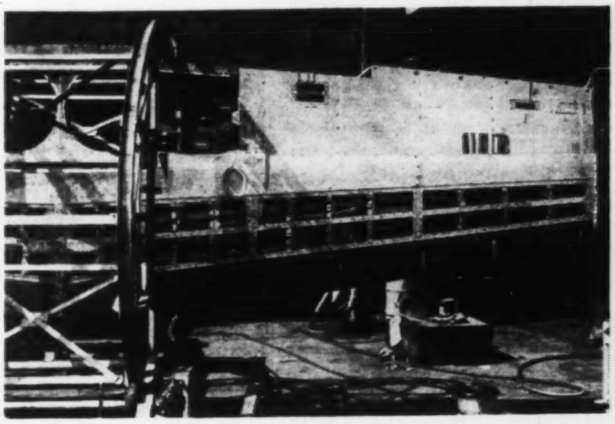


FIG. 13 SKYSTREAK WING SHOWING TUBES CONNECTING ORIFICES WITH RECORDING MANOMETERS

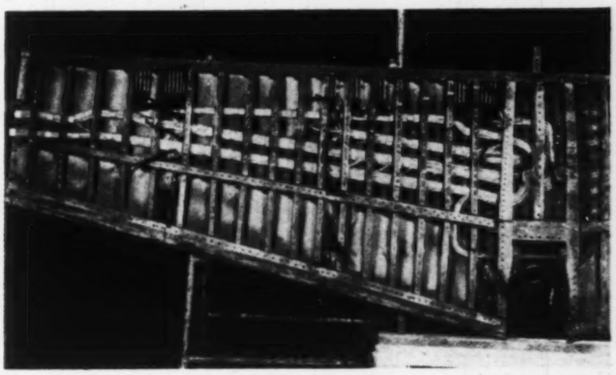


FIG. 14 SKYSTREAK HORIZONTAL STABILIZER SHOWING TUBES CONNECTING ORIFICES WITH RECORDING MANOMETERS

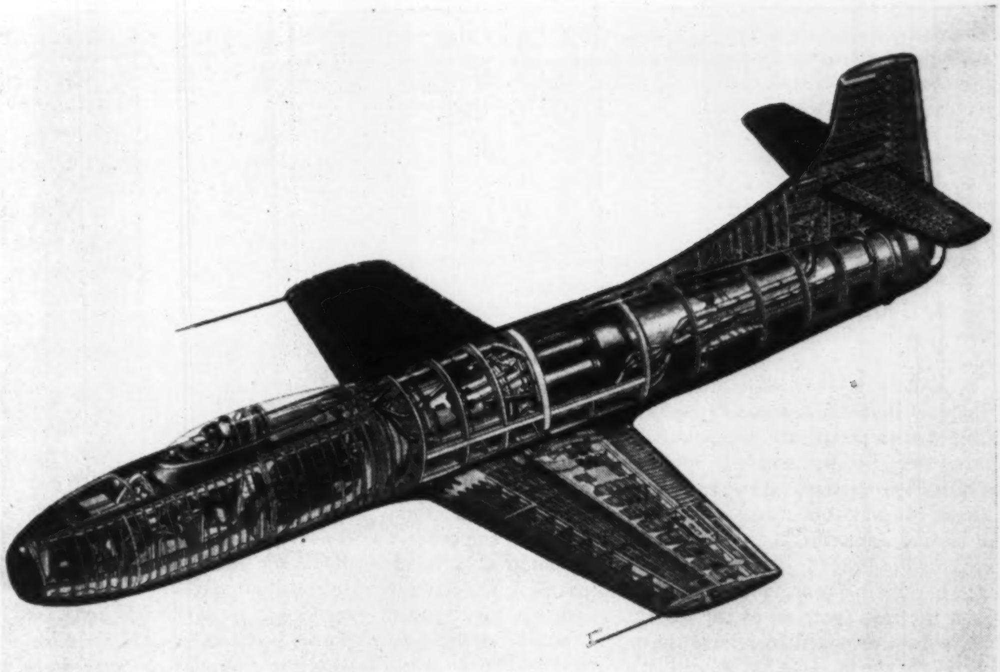


FIG. 12 CUTAWAY VIEW OF THE SKYSTREAK

(Since presentation of this paper, the Skystreak has broken two world's speed records, as follows: Muroc Army Base, Calif., Aug. 20, 1947, official record of 640.7 mph made by Commander Turner F. Caldwell, U.S.N. Aug. 25, 1947, official record of 650.6 mph made by Major Marion E. Carl, U.S. M.C.)

Air pressures are measured at 400 points on the wing and tail surfaces by automatic recording manometers. Figs. 13 and 14 illustrate the routing of the tubes connecting the pressure orifices with the manometers. In addition to the pressure measurements, the wing and horizontal tail surfaces are mounted on the fuselage by means of links equipped with strain gages for the purpose of recording forces and moments.

The actual performance of the Skystreak is still classified as confidential. It can be said, however, that the airplane was designed to explore the high-speed range approaching the speed of sound and has sufficient strength to withstand the speed of sound.

The endurance with normal built-in fuel is approximately 1 hr. With wing-tip tanks, the endurance can be increased to approximately $1^1/_2$ hr.

The space limitations in the fuselage necessitate the carrying of the fuel in the wing. The entire wing is sealed by a Stoner-Mudge sealing material and is completely filled with fuel. Also due to space limitations, and in order to preserve external contours, the major portion of the fuselage was built of magnesium alloy as a semimonocoque structure. There are no conventional stringers and frames are employed only at points of concentrated loads. This was possible due to its small radius of curvature and resulted in a highly efficient structure.

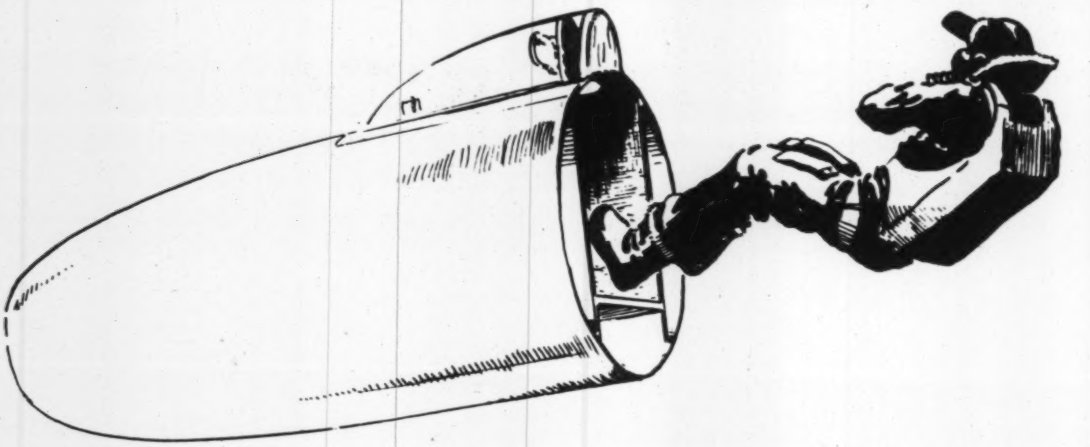


FIG. 15 EMERGENCY EXIT IN WHICH COCKPIT IS JETTISONED

The wing and tail surfaces were built largely of 75S high-strength aluminum alloy. The thinness of the wings made it necessary to resort to the use of tungsten-alloy aileron counterbalance weights instead of the usual lead, as the tungsten alloy employed has a density approximately 50 per cent greater than lead and would fit in a space insufficient for lead counterweights.

Consultation with aeromedical experts indicated that it was doubtful that a human being could survive a normal bail-out from this airplane at high speed. A jettisonable seat was investigated, but the accelerations required to throw the pilot clear of the vertical tail were in excess of human anatomical limits. It was therefore concluded that the only safe method of bailing out at high speed would be to jettison the cockpit as shown in Fig. 15. A release mechanism similar to a bomb rack in principle is provided at four points to release the cockpit from the main portion of the fuselage, with a second release mechanism provided to release the pilot's seat after the nose portion of the fuselage has slowed down considerably to permit a safe bail-out. Normal low-speed bail-out provisions are also incorporated.

To control both heat and cold during the various phases of flight, a refrigeration system has been provided to drop the temperature of the cockpit approximately 100 F, when flying near sea level on a hot day. This same system is arranged to provide heat when flying in the cold upper atmosphere. In addition to the heating and cooling provisions, the cockpit is thoroughly insulated and pressurized.

The original cockpit enclosure was of blown plastic. Tests indicated that its safe working temperature would be exceeded at speeds expected. A glass enclosure with a greater safe working temperature has been substituted.

Although this is purely a research project and has no direct military value, the wisdom of entering into this kind of research has already been proved, as many of the problems solved during the design of this project have been of great benefit to subsequent military projects. A thorough research program planned to extend through another year or two will benefit new airplane designs for many years to come.

CONCLUSION

The progress of aviation in the past has been good, in fact, better than for any other mode of transportation. It is the author's belief that it will continue to be as good or better than it has been in the past. Just what rate of advancement we may experience is extremely uncertain; opinion varies widely among the experts. Therefore the author is inclined to believe that future progress, at least for the next few years, will follow rather closely the progress of the 44-year history of aviation.

Development problems are becoming greater at an increasing rate; scientific research, engineering, and testing will be required in greater amounts; the tasks ahead for the aeronautical and mechanical engineers appear limitless and development costs will be far greater than ever before. In fact, the burden of developing a new high-speed aircraft is so great that it is almost impossible at present for any manufacturer to bear the cost without assistance from the Government. It is hoped that our Government officials and Congress realize the importance of this problem in time to prevent us from ever again being caught in a state of unpreparedness.

RESEARCH AIRCRAFT

By P. B. KLEIN[1]

AIR MATERIEL COMMAND, WRIGHT FIELD, DAYTON, OHIO

THE appearance of the German jet-propelled fighter in the skies over Europe in 1944 indicated quite clearly that enemy advances in the field of aerodynamics and engine development were of such order as would rob us of tactical superiority in the air unless we immediately tackled and solved the problems associated with sonic and supersonic flight. Prior to this time these problems were considered almost as imponderables; certainly they were considered at least very formidable and their solution would materialize only after an extended and energetic program of basic research was initiated and carried to completion.

The pressure of the war precluded any possibility of our immediate switchover to a comprehensive program of jet-propelled-aircraft development at the expense of scrapping our more stabilized program of improving the aircraft we already had in production. The ultimate victory that we won testified most conclusively that the policy which had been adopted in furthering our research and development program was based upon sound logic and proper consideration of the myriad factors involved. But even so we were acutely conscious of the need for getting a purely research project under way without any delay whatsoever; a project which would enable us to explore the sonic- and supersonic-speed range with a view toward discovering exactly what obstacles confronted us and how we might best overcome them.

It was necessary to dig out of the files all the information we could find on compressibility phenomena, roll up our sleeves, and with the help of every scientific mind we could muster for the approaching ordeal, bend to the task of clearing a path through that so-called invisible wall which had threatened to stop our high-speed aircraft. We knew that we now had enough thrust at our disposal to go well beyond this wall once we succeeded in going through it. It was immediately recognized that the many unknowns in this problem would necessitate probing every possible available source of information.

FULL-SCALE FLIGHT MODELS ORDERED

Only after much study and investigation of the problems involved and the results desired did we make any attempt to design a flight article which we hoped would point the way to ultimate success in conquering the problems associated with ultra high speeds. Though considerable information and data on high speeds can be obtained in wind tunnels, from calibrated rocket-powered models, or from freely falling aerodynamic shapes which are properly instrumented and tracked by radar, we soon learned that an actual full-scale flight article would be the only source of the comprehensive data and information we would need if we ever hoped to develop tactical aircraft which would be capable of sustained flight in the sonic region. A series of conferences were held with governmental agencies such as N.A.C.A., Bureau of Standards, Army Proving Grounds at Aberdeen, power-plant manufacturers, and institutions such as GALCIT. During this period many studies were made which culminated in a design for which a letter contract was signed with the Bell Aircraft Corporation on March 12, 1945, calling for the construction of three flight articles.

In setting up specifications for such an aircraft the first consideration or requirement was that it be capable of a top speed substantially above the upper boundary of the transonic region, that is above a Mach number[2] of 1.18. It was decided finally that a Mach number of 2, or a speed of 1350 mph at 30,000 ft altitude was a reasonable mark at which to shoot.

In selecting a design altitude, we wanted to go high enough to avoid the severe structural loading problems encountered in dense air, yet avoid altitudes where turbojet, ramjet, or other air-breathing engines, if used, would lose an excessive amount of thrust. About 35,000 ft would be the upper limit for an air-breathing engine, but there would be no such limit imposed if the aircraft were to be largely or entirely propelled by rocket engines.

We had to have enough endurance at maximum velocity to allow complete observations under stabilized flight conditions. Although a duration of flight of 5 min at maximum velocity doesn't seem like much to ask for, we soon found that we would have to be satisfied with somewhat less, because of the extremely high fuel consumption of the rocket engine—almost one ton of fuel per min.

"MOTHER-AIRCRAFT" LAUNCHING TECHNIQUE

From one viewpoint, it might be desirable to accomplish take-off, subsonic flight, and the landing of our aircraft with self-contained power units. This would reduce maintenance difficulties encountered in the use of auxiliary launching or carrying devices. However, there were so many more advantages in air launching from a mother aircraft at high altitude that this method of launching was finally decided upon. This enabled us to make preliminary glide flights with the aircraft prior to attempting powered flight. Furthermore, it eliminated the danger incident to making heavily loaded take-offs with only rocket power as the source of thrust. In addition, a tremendous saving in fuel is effected, which fuel would otherwise be expended in a rapid climb to flight altitude. Ease of transportation from one test base to another is another advantage of the mother-aircraft launching technique.

Consideration was given to some flexibility in the design of the aircraft to permit changing of major components such as wings, tail surfaces, canopies, etc., as testing and evaluation progressed.

Adequate provision for complete instrumentation was a prime requisite, of course. We would need about 500 lb of instrumentation. Another item that is becoming increasingly important when considering high-speed flight is that of the safety and physical well-being of the pilot. The present-day test pilot must not only be an exceptionally qualified pilot but must also be something of an aeronautical engineer in his own right, if we are to obtain the technical data we want and will

---

[1] Colonel, Army Air Forces, Chief, Fighter Branch, Aircraft Projects Section, Engineering Division, Air Materiel Command.

Contributed by the Aviation and Oil and Gas Power Divisions, and the American Rocket Society and presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of The American Society of Mechanical Engineers.

[2] Mach number is a term which expresses the relationship between a given speed and the speed of sound under the same atmospheric conditions. A Mach number of 1 at sea level represents a speed of approximately 761 mph, at 40,000 feet a Mach number of 1 would represent a speed of approximately 663 mph.

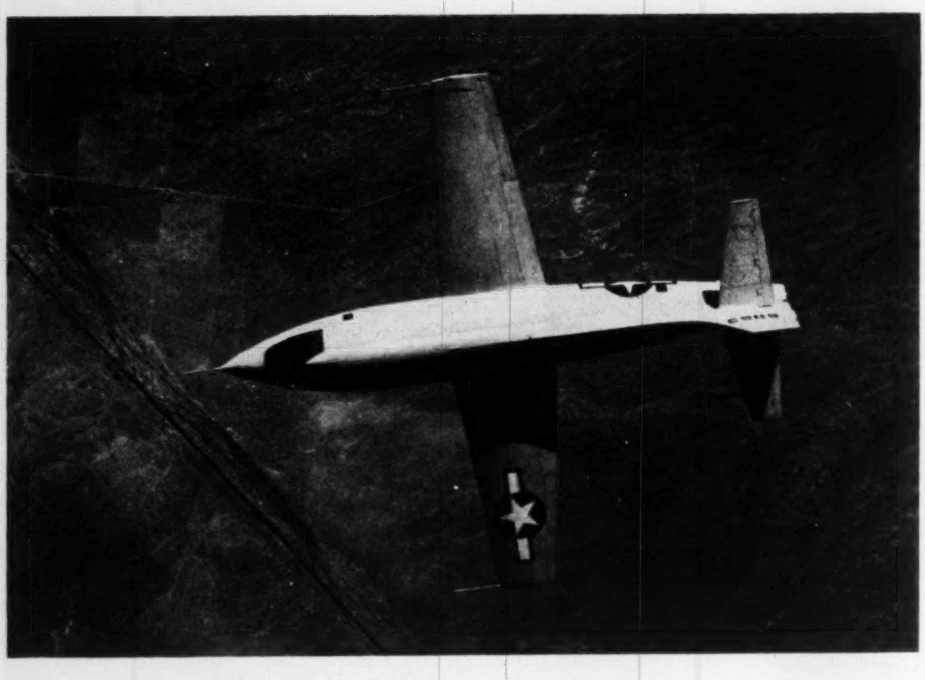


FIG. 1 THE XS-1 IN FLIGHT

need. Certainly, well-qualified test pilots are anything but expendables, and we are definitely obliged to reduce to an absolute minimum any anxiety they may feel as to their safety when testing our aircraft. It appears likely that we will soon be capable of designing aircraft the control of which will be beyond the capabilities of the human being. There is a definite limit to man's reflexes, but there seems to be no limit to what man's mind and intellect can contrive in the way of man-carrying flying machines or projectiles. The time is not too far distant when we will have to admit that God never intended that we should move as fast as the contrivances we put together might carry us, and we will then have to devise something which will not only eliminate the necessity for human manipulation of the controls but will actually perform this function in a manner completely beyond the reach of human capabilities.

TRANSONIC AIRPLANE, THE XS-1

Figs. 1 and 2 show the XS-1 the construction of which was the end item of all of our efforts to design and build a transonic airplane. It is rocket-powered, employing alcohol and liquid oxygen as the propellants with four 1500-lb-thrust motors, permitting about 2 min of full thrust operation. The airplane has a conventional configuration with a wing having about 130 sq ft of area, A.R. approximately 6, and a span of about 30 ft; the over-all length is about 30 ft. No sliding canopy is provided over the pilot's cockpit; he enters through a rectangular door, located on the side of the fuselage, which is flush with the contour. The pilot is enclosed entirely within the lines of the fuselage in a sealed compartment.

The airplane has a gross weight of about 13,000 lb when fully loaded and a landing weight of about 5000 lb, which results in wing loadings of about 100 psf and about 37 psf, respectively.

To reduce stick forces and control sensitivity, small chord-control surfaces were used. No aerodynamic balance was provided to avoid the possibility of overbalance at supercritical speeds. With the large and rapid changes of trim expected when the airplane is operating in the transonic region, it was believed that the elevators would not suffice, so a power-operated, adjustable stabilizer was installed, designed to operate at a rate of about $^1/_2$ deg per sec.

During the early stages of the XS-1 design, the war was still in progress and it seemed quite unlikely that an airplane like the B-29 could be made available for use as a "mother" airplane for this project. For this reason the XS-1 was designed with a landing gear which would permit it to take off from a runway under its own power. Furthermore, with the war still in progress, and the possibility of a similar airplane being used tactically, a landing gear seemed desirable.

SELECTING A POWER PLANT

After reviewing the power-plant field, only the turbojet and rocket were seriously considered for this application. Preliminary studies indicated that an airplane designed around existing turbojets, using the thrusts given in the engine specifications, would not attain the desired speeds at the desired altitude. It was found that speeds in the region of only M = 0.90 could be attained at sea level, and altitude performance was considerably less. Turbojet-engine manufacturers were then contacted on the possibility of increasing their engine outputs at altitude by 100 per cent or more for short periods of time by any means they could devise. The general reaction was one of great interest. However, very little theoretical work and practically no testing had been done on thrust augmentation at that time, and the pressure on production models, brought on by the war, prevented any development in connection with such a specialized project.

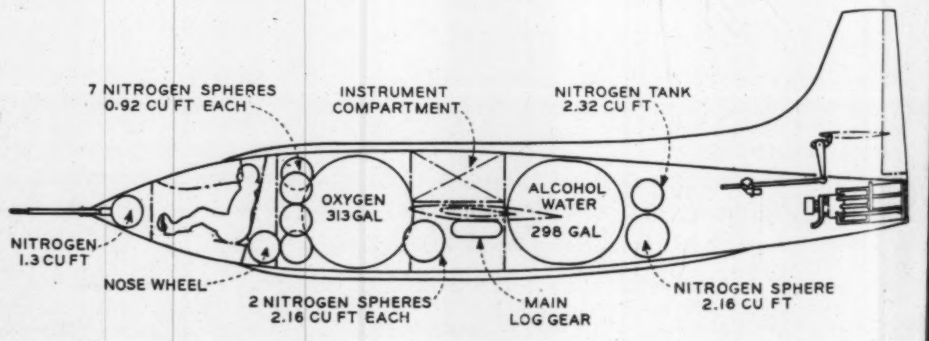


FIG. 2 INBOARD PROFILE

Consideration was then given to the combination of a turbojet and rocket power plant. The primary purpose of the turbojet was for take-off, climb to altitude, and return to the home base. The rocket was to accelerate the airplane to—and maintain the desired speed after—the operational altitude had been reached. This study resulted in an excessively large airplane. The turbojet performance fell off at altitude, resulting in a poor rate of climb, which in turn called for a large amount of fuel. The speed at which the airplane was flying when the operational altitude was reached was also low, requiring a considerable amount of rocket fuel for acceleration purposes. The use of two such widely different power plants also increased the installation and operational problems. Although the fuel consumption of an all-rocket-powered airplane was high, the rate of climb was also high, averaging better than 20,000 fpm between sea level and 35,000 ft, with a climbing speed of 500 mph. Thus, the fuel required for climb was relatively low and that required to accelerate from climbing speed to the desired test speed was less than with a combination turbojet and rocket. At higher altitudes the potential climbing speeds and rate of climb were even higher, reaching maximum values of approximately 120,000 fpm at an altitude of 120,000 ft, flying at nearly 1400 mph. After a comparative analysis of the design studies made around the various power plants, it was decided to proceed with the all-rocket-powered airplane.

ROCKET-MOTOR PROPELLANTS

Many propellants were considered before liquid oxygen and ethyl alcohol were selected. Hydrogen peroxide was discarded because the motors in operation at that time exhibited low specific impulses. It was available in this country only in limited quantities, and it must be handled with a great deal of care. Acid and aniline were not considered suitable for a man-carrying aircraft. These propellants are spontaneously combustible, which necessitates special precautions being taken to keep them separated, since any dual leak into the air might initiate a disastrous fire or explosion. Acid is also injurious to personnel, which complicates the handling problem. Nitromethane, being a monopropellant, would simplify the fuel system considerably, but it is subject to detonation under certain conditions which (at that time) were not too well understood. Although it was believed that nitromethane had good possibilities, it was not felt that it had been developed to the point of reliability desired. Gasoline and liquid oxygen were studied, but, with a regeneratively cooled motor, it would have been necessary to carry a third tank containing water aboard for this purpose, as gasoline is not a suitable cooling medium.

The propellants selected, liquid oxygen and alcohol, are readily available and have a good specific impulse. A value of about 190 lb of thrust per lb of fuel per sec was used in the design. These materials are relatively safe and easy to work with; they are not spontaneously combustible, the fuel is noninjurious to personnel, and small splatters of liquid oxygen are not harmful. The motor is regeneratively cooled by circulating the fuel through a cooling jacket before it is injected into the combustion chamber. To aid in cooling, 1 part of water is mixed with 3 parts of ethyl alcohol. It was found that the addition of this amount of water had a small effect on the over-all impulse but aided appreciably in the cooling problem.

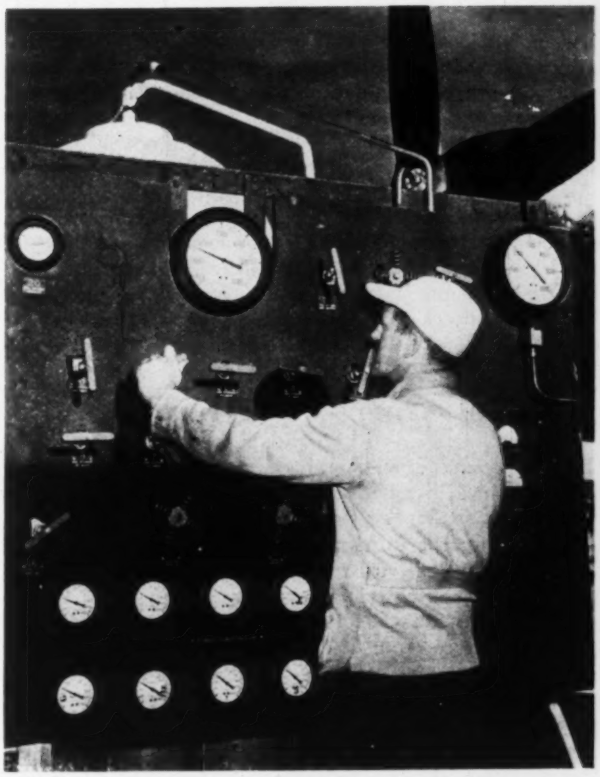


FIG. 4 LIQUID-NITROGEN EVAPORATING SYSTEM CONTROL PANEL USED IN PRESSURIZING NITROGEN GAS SPHERES IN THE XS-1

The motor which was designed and built by Reaction Motors, Inc., consists of an assembly of four rockets of about 1500 lb thrust each, operating at a chamber pressure of approximately 230 psig.

Because of the high combustion temperature, approximately 5000 R, and the relatively long time the motors must operate, some form of cooling was required. Injecting an excess of fuel to reduce the combustion temperature would have been very inefficient; "sweat" cooling, in which the cooling fluid is forced through a porous combustion chamber and nozzle wall and vaporized, was just a gleam in someone's eye and has not progressed much farther up to the present date. Regenerative cooling with some film cooling was em-

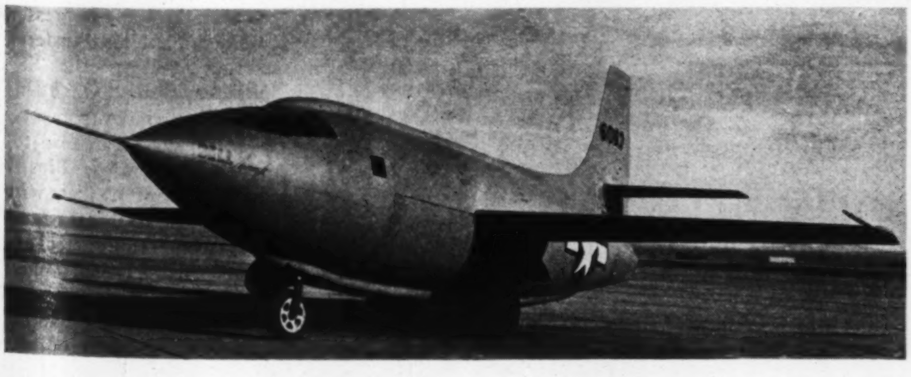


FIG. 3 AIRCRAFT DESIGNED FOR TRANSONIC FLIGHT

ployed on this motor, that is, the fuel was circulated around the combustion chamber in a cooling jacket before being burned. In the region of the converging section of the nozzle, where the hot gases impinge directly against the nozzle wall, the cooling problem is more difficult. Here, small holes, approximately No. 70, are drilled through the nozzle wall into the cooling jacket, which permits a small amount of fuel to flow in a thin film over the nozzle.

The rockets may be run separately or in combination as selected by the pilot. The motors are started by a small igniter located in the forward end of the cylinder, which fires a stream of fuel and gaseous oxygen by means of a spark plug. When the chamber pressure reaches a value of approximately 50 psi, the propellant valves open admitting the fuel and liquid oxygen.

INTERNAL ARRANGEMENT OF THE XS-1

The items of primary importance in the internal arrangement of the XS-1, are the fuel tank, liquid-oxygen tank, turbopumps, rocket motor, instrumentation compartment, and cockpit. Fig. 3 shows the inboard profile with a pressurized fuel system substituted for the turbopumps. As originally designed the XS-1 was equipped with turbine-driven pumps to supply the motors with the two propellants, the turbine pumps employing the same fuel used for the rockets. The pumps are required to deliver about 860 lb of fuel, and about 1012 lb of liquid oxygen per min or a total of nearly 1 ton of propellant per min at a pressure of approximately 350 psi, when the motors are operating at full rated thrust. To prevent cavitation, the propellants are supplied to the pump inlets under pressure. This is accomplished by pressurizing the propellant tanks with gaseous nitrogen.

The fuel tank is essentially an integral tank with a bag liner. The liquid-oxygen tank is made of aluminum alloy supported around its circumference by the fuselage structure. It may be of interest to add at this point that the physical properties of some materials such as the aluminum alloys commonly used in aircraft and stainless steel improve at the extremely low temperature of liquid oxygen, approximately —300 F. Because the propellant weight is such a large proportion of the total weight, center-of-gravity control during flight, with the airplane in a steep climbing, diving, or level-flight attitude, became a serious problem. This was overcome by dividing each of the two tanks into three separate compartments. The tank pressure and venting lines were so routed that the forward compartment of the liquid-oxygen tank and the aft compartment of the fuel tank were emptied first; next the two center compartments were drained, and last of all, the two remaining compartments. This method of draining, plus proper proportioning of the compartments, held the center-of-gravity travel down to about 2 per cent of the M.A.C. for any flight attitude and to considerably less than that for level flight.

Early in the design it was believed that a turbine-driven pump would not be available at the time the XS-1 was ready to fly. To avoid any unnecessary delay in the flight date, an alternate pressure-feed propellant system was designed and built by Bell, as shown in Fig. 3. This belief has since been confirmed, and the XS-1, which has been making powered flights at Muroc, Calif., since December, 1946, is equipped with a pressure-feed fuel system. In this version, the low-pressure propellant tanks were replaced with high-pressure tanks and high-pressure gaseous nitrogen tanks were substituted for the turbine pump.

PRESSURIZED FUEL SYSTEM

To assure sufficient pressure in the motor chambers, it was necessary to design both propellant tanks to operate at a pressure of more than 330 psig. This high design pressure, coupled with the ever-present weight problem, dictated the use of spherical tanks which do not lend themselves to efficient use of space. The largest tanks that could be installed within the confines of the fuselage were designed; even so, the duration at full thrust was reduced to about 2 min. Although the take-off gross weight was reduced approximately 1000 lb the landing weight was increased nearly 2000 lb.

To carry sufficient nitrogen gas aboard to pressurize the two propellant tanks (which had a total capacity of approximately 600 gal plus about 20 per cent additional gas to make up for the amount which condenses and goes into solution with the liquid oxygen), in the small space now available in the XS-1, it was necessary to employ several relatively small N_2 spheres ranging from about 15 in. to about 21 in. diam and pressurize them to over 4000 psig.

This again presented another problem. N_2 can be obtained commercially only up to 2200 psi, and no pumps were available that could deliver uncontaminated gas at the desired pressure. To accomplish this, a liquid-nitrogen evaporator was designed and built which evaporates the liquid into a gas at over 4000 psi. The gas may be stored in pressure cylinders until it is transferred to the XS-1, or the XS-1 spheres may be charged directly from the evaporator.

The sphere located on top of the evaporator, Figs. 4 and 8, is about 3 ft diam with a very thick wall cast in two halves from stainless steel and welded together. This sphere has been hydrostatically tested to 9000 psi. During the testing of the evaporator we had a rather interesting experience. While filling the

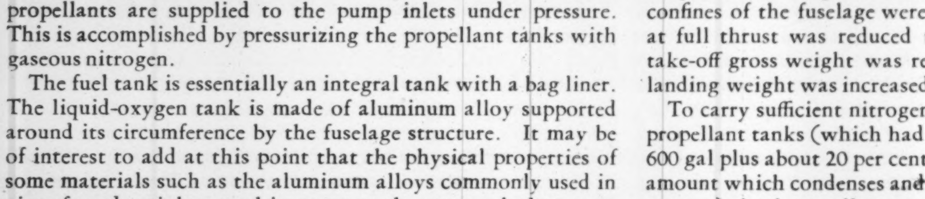


FIG. 5 INSTRUMENTATION IN COCKPIT OF THE XS-1

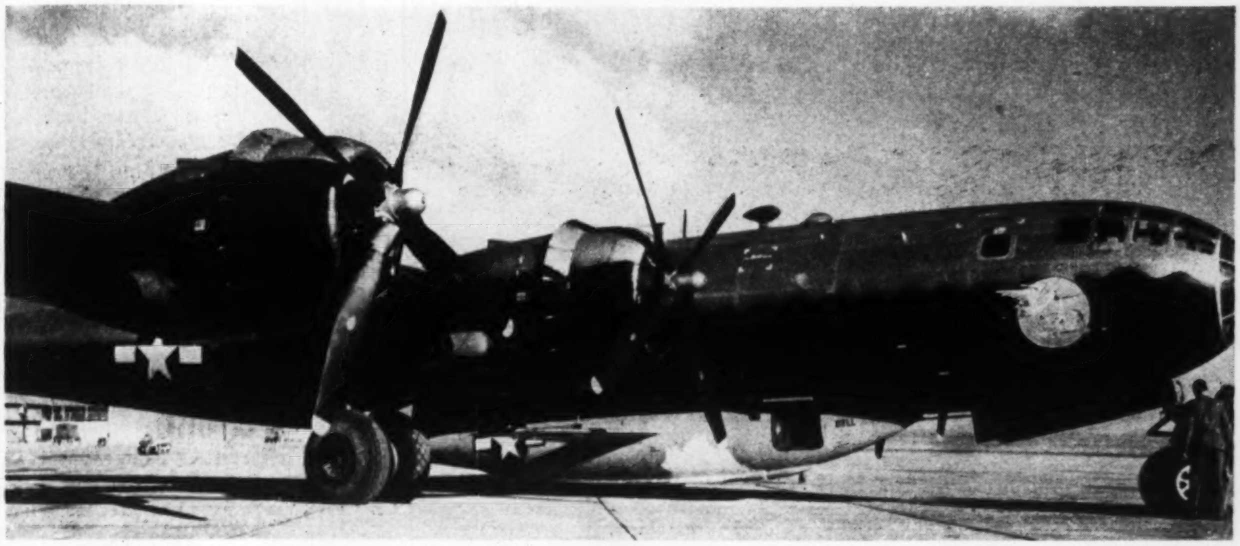


FIG. 6 B-29 USED AS MOTHER AIRCRAFT FOR THE XS-1

evaporator, it was noticed that a film of liquid covered the various lines in which there was nitrogen, dripping from the joints and connections. This was quite baffling in view of the many pressure tests that had been run previously. After the lines and joints had been checked and rechecked for leaks with none being found, it was discovered that oxygen was being condensed out of the air on coming in contact with the cold nitrogen lines.

All the pressure tanks in this version of the XS-1 were designed to yield at their operating pressures times a factor of about $1^1/_2$. The nitrogen tanks were made from a Great Lakes alloy, varying in thickness from about $^1/_4$ in. to about $^5/_8$ in., depending upon their diameter. The liquid-oxygen tank was made from annealed stainless steel. Considerable trouble was experienced with the high-pressure joints in the fuel system. As a result, most joints are welded with as few high-pressure fittings as possible.

STRUCTURAL-DESIGN PROBLEM

The structural-design standard for the aircraft was difficult to determine, but the criteria used were believed conservative and in most cases quite arbitrary. In general, the airplane was to be designed to about 18 g ultimate.

Two sets of wing panels were made for the XS-1, one about 10 per cent thick and the other about 8 per cent. The maximum wing thickness was less than 8 in. in one case, and less than 6 in. in the other, and with the 18 g design requirement, conventional wing construction was not feasible. Instead, machine-tapered skin was used to carry the bending loads. The skin was aluminum alloy machine-tapered from about 0.50 to about 0.13 for the 10 per cent wing, and about 0.60 to about 0.16 for the 8 per cent wing. Shear was carried by 5 relatively light spanwise channels, some of which were dropped in the outer portion of the wing.

The 240 pressure pickups and 12 strain gages located in the wing presented somewhat of a problem because of the limited space available; 240 $^3/_{16}$-in-OD tubes ran from the pickups to the center section of the fuselage where the N.A.C.A. manometer cells are located.

Two sets of stabilizers were also made, one about 8 per cent thick and the other about 6 per cent. Instead of a machine-tapered skin, however, a laminated construction is used with two laminations at the inboard end and one thickness at the outboard end.

The fuselage is conventional semimonocoque construction made from aluminum alloy.

Fig. 5 shows a sketch of the cockpit interior. It is much smaller than the cockpits used in present-day fighters. No pressurizing equipment is used. Instead, the cockpit is designed as a sealed compartment and tested to lose not more than 1 psi per hr with an initial pressure differential of 3 psi. A wheel control was provided so the pilot can use two hands effectively if the need arises. The wheel incorporates a motor-selector handle, instrumentation switch, and an emergency motor cutoff, so located that the pilot will not be required to remove his hands from the wheel to operate any one of them. To prevent frosting and fogging, a double-glazed windshield was installed, incorporating a silica-gel capsule for drying purposes. In addition, the pilot exhales through another silica-gel container built into his oxygen mask.

The control system is conventional, using push-pull tubes in the cockpit and tension rods aft of the cockpit, running through the dorsal fin. Hydraulic dampers have been designed and built and will be installed in the elevator, rudder, and aileron control systems to reduce, or possibly eliminate, flutter or buzz.

With the supply of gaseous nitrogen aboard, it was decided to use a pneumatic auxiliary power system. The landing gear and flaps are actuated by pneumatic cylinders, while the stabilizer is adjusted through a screw jack, actuated by a pneumatic motor. The system has proved itself to be entirely satisfactory.

B-29 FITTED AS MOTHER CRAFT

As already noted, at the close of the war, with the resulting surplus of B-29's, it seemed much more prudent to launch the XS-1 from a mother airplane at altitude and thus eliminate the hazards associated with high-speed take-offs and low-altitude flying with an aircraft having as many unknowns as this one.

Accordingly, a B-29 was supplied by the Army Air Forces and modified by Bell Aircraft to carry the XS-1 (Fig. 6). The bomb doors were removed and the XS-1 was suspended from a standard Army Air Forces D-4 bomb shackle. An enclosed ladder was also installed between the B-29 and XS-1 in such a manner that the XS-1 pilot or flight personnel could go back and forth between the two airplanes while in the air.

This method of launching increased the "potential" speed and duration of the XS-1 appreciably, providing control could

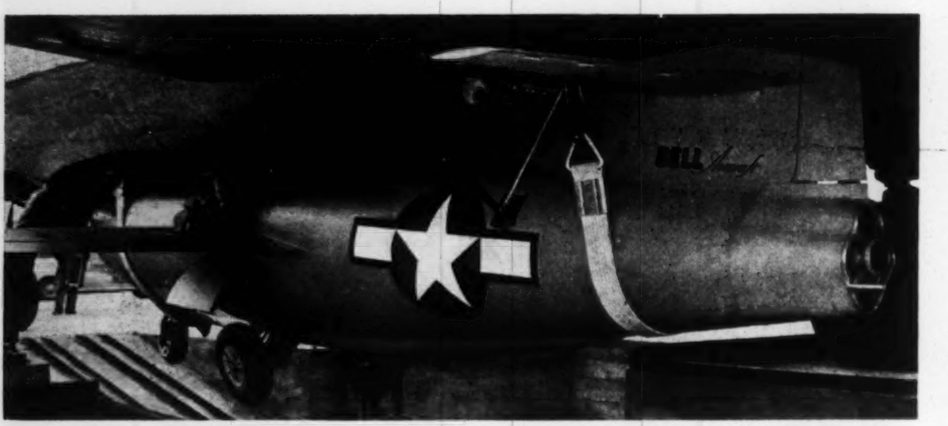


FIG. 7 THE XS-1 IS LIFTED FROM A PIT INTO THE B-29

be maintained. For example, the maximum potential high speed (the word potential is emphasized because it is not desired to imply that the plane can or will ever achieve such speed) with ground take-off was computed to be about 1100 mph at 70,000 ft. With air launch this was increased to approximately 1700 mph. The 1100-mph speed computed for ground launch provided for no stabilized flight, that is, the XS-1 would first climb to 70,000 ft and then accelerate to about 1100 mph, at which time it would run out of fuel. With air launching, the XS-1 might maintain a stabilized flight in the neighborhood of 1100 mph for better than 2 min. Even with air launch the maximum potential speed is limited by fuel supply above 50,000 ft and not by thrust available.

A plexiglas windshield was provided on the original design. This was satisfactory at the time as the anticipated speeds and flight durations were low enough to keep the glass temperature, due to aerodynamic heating, down to a safe value. In addition, the windshield is curved in two planes as it was thought wise to avoid the problems associated with double-curved plate glass if possible. However, with the potential increase in flight speeds and durations gained by air launching, it became mandatory that a windshield be installed which could withstand elevated temperatures. As a result, plate glass is now being substituted for the plexiglas windshield.

GLIDING TESTS

During February of 1946 ten glide flights were made by the XS-1 at Pinecastle, Fla. This site was selected because Muroc Dry Lake was flooded at the time and 10,000-ft runways were available at Pinecastle, although only 3000 ft were ever used. The XS-1 was launched at approximately 27,000 ft and glided to the ground in about 12 min, making a normal landing at a speed of around 110 mph. In that every landing is a dead-stick landing, spoilers were provided for flight path control. They did not prove to be too successful and were not used on later drops.

For loading purposes the XS-1 is lowered into a pit, the B-29 rolled over the pit and the XS-1 pulled up and partially into the B-29 by means of a hoist located in the mother airplane, Fig. 7.

Although no launching difficulties were anticipated, certain precautionary measures were taken prior to the first flights to assure no fouling between the XS-1 and B-29 on release. A pressure survey of the XS-1 wing was made in flight while attached to the B-29. This was accomplished by running lines from the pressure orifices in the XS-1 wing to manometers located in the B-29. The survey indicated a download or separating force of approximately 1000 lb between the B-29 and XS-1. A pneumatic ejection cylinder also was installed in the B-29 to assist in separating the two airplanes. In addition, guide rails were installed on the B-29 to prevent the XS-1 from sliding back too rapidly until completely clear of the mother airplane.

During the 10 glide flights, drops were made with the B-29 operating at various powers and with various flap settings, and with the inboard props of the B-29 feathered as well as set for normal operation. The tests were completely successful. All the precautionary measures were found to be unnecessary and the various power and flap settings of the mother airplane had little or no effect on the launching characteristics.

FLIGHT TESTS WITH ROCKET POWER

Final preparations were then started for the power tests which were to be made at Muroc, Calif. Facilities were set up at Muroc to handle this operation. A large storage tank for liquid oxygen and a somewhat smaller tank for liquid nitrogen were erected. A mixing tank for the alcohol and water was provided by reworking a small Army fuel trailer and a loading pit was dug. Fig. 8 shows the XS-1 being loaded with fuel, oxidizer, and gaseous nitrogen.

A series of ground tests was run on the fuel system and power plant, checking out the power-plant controls, pressure regulators, valves, and so on, terminating in a number of power runs on the rocket motors with the airplane tied down. In case of emergency, provisions have been made for jettisoning both fuel and liquid oxygen.

After completion of the ground testing, additional glide flights were made. The last glide flight consisted of loading the XS-1 with fuel and jettisoning it on the way down. Following this, the first powered flight was made.

The B-29 was climbed to an altitude of 27,000 ft. Approximately 10 sec after the drop, chamber No. 1 was ignited. The pilot stated he could not "feel" the actual starting of the motor. Shortly thereafter, chamber No. 2 was fired and a slight acceleration was felt by the pilot. Speed of the aircraft picked up rapidly and chamber no. 2 was cut off. A slow climb was then entered at an indicated speed of 330 mph, using one chamber at a time for a few seconds. The noise level in the cabin was very low. At an altitude of 35,000 ft, with chamber No. 1 already firing, No. 2 was ignited. The acceleration was quite noticeable; a Mach number of 0.75 was attained very rapidly and chamber No. 2 was shut off. The pilot then cut off all power, glided to 15,000 ft, ignited all four rockets and started a climb to the vicinity of 40,000 ft. The pilot experienced a very high acceleration, comparable to that experienced in a conventional fighter with water injection from a standing start. The flight was completed in a satisfactory manner with no adverse handling characteristics being reported. On the first flight, the XS-1 had flown at a Mach number of something over 0.75 in a climb while still accelerating. With this reserve of power, an indication is obtained of its potentialities for continuing the progress toward the attainment of sonic speeds in human flight.

APPROACHING SUPERSONIC ZONE CAUTIOUSLY

Up to the present the XS-1 has been flown only to something over Mach 0.80. We are being extremely cautious in approaching the speeds where we anticipate some trouble with compressibility. We first want to be certain that when we do venture into the transonic region we have an aircraft strong enough and controllable enough to cope with whatever unpredictable effects may be manifested. Maybe we are on the verge of piercing the barrier. On the other hand, it may be many months yet before we succeed in flying at sonic speed. Between now and then we are not at all certain what we will experience. Perhaps our concern is needless and our fears unfounded. However, we are exploring new horizons and a region where no human has ever trod before. We are quite willing to admit that we do not know and cannot predict with any reasonable hope of accuracy when we will be able to move faster than the speed of sound.

XS-1 DESIGNED FOR TRANSONIC SPEEDS

Before leaving the discussion of the XS-1, I would like to clarify one point which has caused some misunderstanding in regard to the mission the XS-1 was designed to perform. Contrary to press notices which attended the release of XS-1 publicity some time ago, the XS-1 was designed to explore the "transonic" region and provide us with actual flight data which might enable us to build a "supersonic" airplane in the near future. It is true that the XS-1 may be capable of supersonic flight and may actually fly at Mach numbers in excess of 1.5, but attainment of such speeds is actually beyond the airplane's original mission.

We believe that once we are through the sonic region where the compressibility phenomenon manifests itself, we will once again be in a region where a stabilized flow of air around our airplane can be established and normally controlled flights will be possible. The thrust required to get us through this region may actually be somewhat greater than is required to stay on the other side. Consequently, any aircraft designed to fly transsonically must have enough thrust to enable it to fly supersonically once the compressibility region is successfully negotiated. We actually know more about aerodynamics in the supersonic region than we know about aerodynamics in the transonic region. So, the potential performance capabilities of our XS-1 in the supersonic region are "projected" calculations only and can be obtained only if nothing disastrous occurs in the transonic region on the way up. The problem in reality is "how can we reach sonic speed and still have an airworthy craft to proceed on up into the ultra-high-speed supersonic range." If the XS-1 can lead the way and answer this question for us we will be most pleased. But if it cannot, or does not, we will not be too disheartened because it was never really expected that it would.

OTHER RESEARCH-AIRCRAFT PROJECTS

We have other research aircraft under construction which we hope eventually will give us the answers beyond the limits of the XS-1. Security classification of these projects will permit me to speak of them only in a general way. All of them are rather unconventional in appearance in that they have either swept-back wings, very thin wings with a very small aspect ratio, or are tailless or semitailless. At least one of them is designed primarily as a supersonic aircraft while another is designed for a high subsonic flight research.

There are still a great many dark spots in the subsonic region which we are particularly anxious to have illuminated because for quite some time yet most of our flying will be done at subsonic speeds. This is particularly true of bomber aircraft, because we still do not have engines that will provide the thrust necessary for supersonic flight and, at the same time, give us the range that we feel we must have. Due to induced high-velocity air flow around fillets, nacelles, canopies, wing junctures with the fuselage, and so on, some part or parts of an aircraft may be affected by compressibility when the aircraft is flying at Mach numbers as low as 0.70. Even our sleekest new bombers will experience compressibility troubles before they reach a Mach number of 0.8, such troubles being manifested by buffeting, aileron buzz, extreme pitching moments, wide variation of trim or other such effect. So, it is quite apparent that we still have a lot of investigating to do in the subsonic region.

Whereas until recently aircraft development followed a process of simple evolution, the advent of the turbojet engine, the rocket engine, and some entirely new concepts of aerodynamics phenomena, have forced the development of aircraft into a process of revolution. Not 15 years ago we were firmly convinced and could prove (we thought) that an airplane could not be designed that would fly faster than 500 mph; then we said 550 mph; then 625 mph; and finally we were forced to hedge a bit and say, well at any rate when and if we get to sonic speed we will definitely be finished. Even that limit has been removed now, and we feel reasonably safe in saying that, in so far as we know, there is no limit as to how fast a man-carrying aircraft can be made to fly.

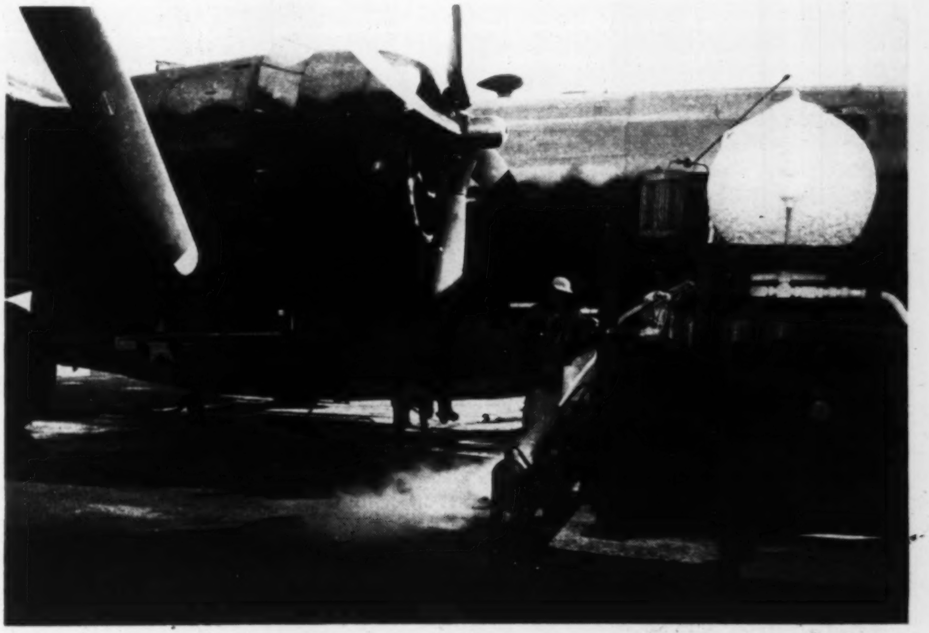


FIG. 8 THE XS-1 BEING LOADED WITH FUEL, OXIDIZER, AND GASEOUS NITROGEN FOR TEST FLIGHT AT MUROC, CALIF.

Elimination of WASTE PRODUCTS *of* HIGH MOISTURE CONTENT *in a* GAS-TURBINE SYSTEM

By J. H. POTTER

DEPARTMENT OF MECHANICAL ENGINEERING, JOHNS HOPKINS UNIVERSITY. MEMBER A.S.M.E.

LATE in 1943, a Board of Advisory Engineers[1] was appointed by the City of Baltimore to study the collection and disposal of refuse (1).[2] During the investigation the new incinerator plant (2) at Atlanta, Ga., was visited. This installation was of considerable interest, as the heat released by the combustion of the refuse is used to generate steam. The steam is sold to a local utility, providing revenue with which to retire the twenty-year bonds which financed the plant expansion (3).

Subsequently, Mr. Woodward and the writer canvassed the possibility of applying a gas-turbine cycle to the recovery of energy from fuel substances of high moisture content. Such a system was devised and was later patented (4).

SOME FUELS OF HIGH MOISTURE CONTENT

The combustion of waste products may be desirable either for the protection of health or for the elimination of a bulk substance of low value. A number of unusual fuels are in use in localities where one or both of these criteria are to be met, and in some cases the destruction of a by-product is an important link in an over-all process. This is especially true of the wood industries where power and steam for fabricating and kiln-drying are provided from combustion of the scrap wood.

(*a*) *Wood.* In general wood fuels are classified as wood waste, hogged fuel, or briquets. Wood waste is refuse from the sawmills and consists of sawdust, shavings, bark, and chopped-up trimmings. The hogged fuel has been sized by passage through a disintegrator. If the sawdust is predried and pressed into briquets, a convenient domestic fuel is provided, having a heating value which may exceed 10,000 Btu per lb (5).

(*b*) *Bagasse.* The fibrous matter remaining after the sugar cane has been pressed is known as bagasse. It is characterized by high moisture content and contains some sucrose. The heating value of the dry bagasse ranges from 8000 to 8700 Btu per lb (6). It can be made into briquets if air-dried until the moisture content ranges from 10 to 15 per cent, and such briquets have been used as locomotive fuel. In Cuba (8) bagasse was proposed as a partial substitute for fuel oil in World War II. It may be stored without danger of spontaneous combustion (9); in Hawaii it is sometimes kept for 12 months before it is burned.

(*c*) *Pulp-Mill Waste.* In the manufacture of paper pulp by the acid-sulphite process, a sulphite liquor is recovered which contains the organic matter dissolved from the wood in the pulping process. Essentially the organic matter is lignin substance and carbohydrates. A process of precipitation and filtration has been described by Keeth (10), in which a lignin fuel cake is produced. The moisture content of the cake is reduced 15 to 18 per cent in a press, after which it is burned. A vast quantity of this fuel is potentially available, as most of the waste sulphite liquor is now thrown away.

TABLE 1 SAMPLE ANALYSES OF HIGH-MOISTURE FUELS

PROXIMATE ANALYSIS

Reference	(15)	(6)	(10)	(23)[a]
Per cent composition	Wood waste	Bagasse	Pulp-mill waste	Mixed refuse
Moisture	47.0	50.0	45.97	49.35
Volatile	39.7	..	...	34.45
Fixed carbon	11.7	..	...	6.76
Combustible	...	25.5	29.64	...
Ash	0.7	1.5	10.40	9.34[b]

ULTIMATE ANALYSIS

Reference	(19)	(6)	(10)	(18)
C	50.3	45.0	46.68	29.0
H_2	6.2	6.0	4.11	6.0
O_2	43.1	45.6	23.28	40.0
N_2	0.04	0.4	0.53	4.0
Ash	0.37	3.0	21.28	21.0

[a] Based on a mixture of 65 per cent garbage and 35 per cent rubbish.

[b] Includes other noncombustibles.

(*d*) *Refuse.* The disposal of garbage and rubbish has long been recognized as a prime health problem. The principal methods of elimination have been sanitary land fill, open dumps, scows, and incineration. A recent survey (11) of 1316 cities showed that only 220 were using incineration, and that open dumps accounted for 50.2 per cent. The decomposition of the organic matter is a slow process, and noticeable odors are often present after 2 years in land fills (12).

The composition and moisture content of refuse undergoes seasonal changes, and in most cases it is necessary to mix rubbish, i.e., trash, with garbage, to hold the total moisture content to a combustible level. Moist refuse will range in heating value from 3000 to 3600 Btu per lb.

Sample analyses of each of the foregoing high-moisture fuels are given in Table 1.

COMBUSTION

It is evident from the foregoing that removal of the moisture is essential to successful combustion. In general, radiant heat plus convection is relied upon to dry the charge. Boiler practice (13) with bagasse inclines toward a dutch-oven combustion chamber with or without a low refractory arch, and using either a hearth or grates. Long sloping grates with a suspended arch are also used. Eigenhuis (14) describes such a unit, in which the bagasse is fed at the top of a 60-deg inclined grate. The charge burns as it moves down the grate meeting separate air streams for drying, primary air and secondary air.

The dutch oven with an ignition arch is used also in hogged-fuel and sawdust boilers, even when preheated air is used (15)

---

[1] This board was composed of Hiram W. Woodward, Abel Wolman, and Gustav Requart.

[2] Numbers in parentheses refer to the Bibliography at end of paper.

Contributed by the Process Industries Division and presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of The American Society of Mechanical Engineers.

sewage plant, at an estimated annual saving of $113,000. The sewage plant effluent is then used as circulating water in the condenser of the turbogenerator.

European incinerator practice has been cited previously, and in general the high cost of fuel has spurred inventiveness in this field. An interesting example of power generation exists in Paris (21), where 70,000,000 kw are produced annually from incineration. Steam turbines are used with superheaters and economizers added to the boiler plant. The clinker is ground up and used in concrete aggregates and as raw material in the manufacture of bricks.

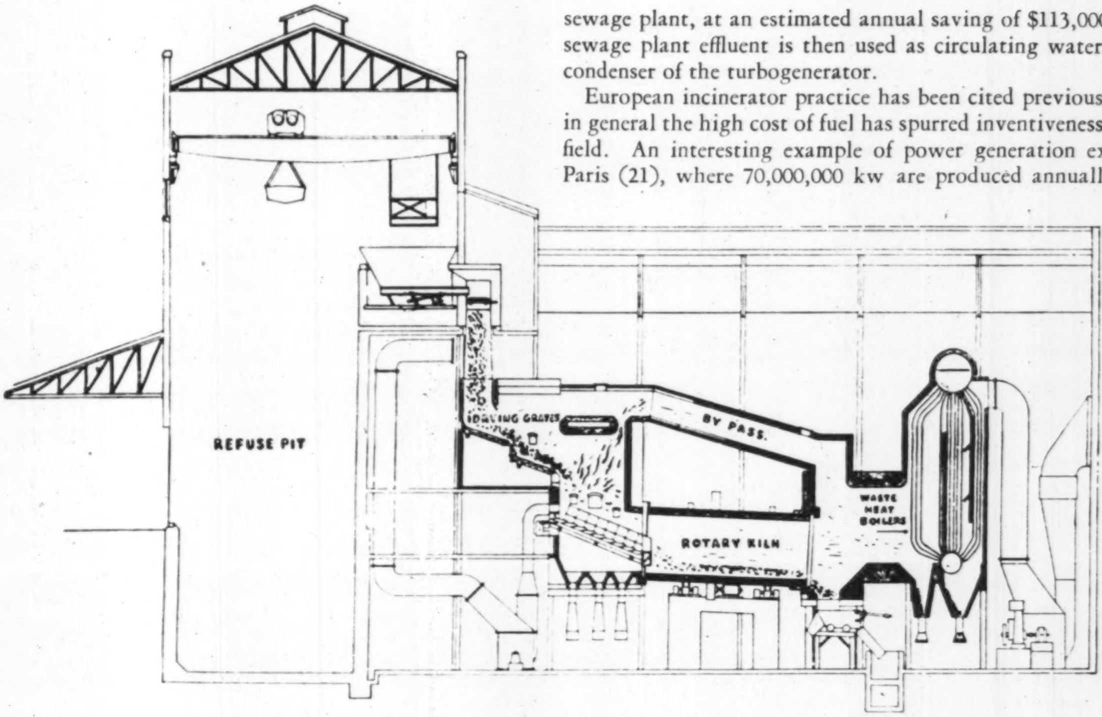


FIG. 1 WASTE-HEAT RECOVERY PLANT AT ATLANTA, GA.

Most of the incinerator plants are primarily refuse destructors, and only a few designers have considered waste-heat recovery. In Denmark, a continuous incinerator was used in connection with a three-drum bent-tube boiler for the generation of by-product steam (16). The Atlanta plant (2) embodied many of the same features; it may be seen in Fig. 1.

Here the wet refuse is dropped from a charging hopper onto drying grates where the moisture is evaporated due to the radiant heat from the fire. The charge is then moved downward to the ignition grates where most of the burning takes place. A rotary kiln moves the slower-burning material toward an ash hopper near the gas intake of the waste-heat boiler. Saturated steam is generated at 175 psig and sold to a local utility.

ENERGY RECOVERY

Economic considerations dictate both the type and extent of energy recovery. Hersey (17) details them as follows:

1 Lack of a market for steam or electricity near the site of the incinerator.

2 Need for greater capital investment.

3 Possible hostility of utility companies holding franchises for steam and/or power.

4 Need for auxiliary fuel to meet variations in quality and quantity of waste fuel.

In many cases these serious obstacles have been successfully met. The installation at Atlanta indicates what may be accomplished when it is feasible to link a municipal service with an operating utility.

At Providence, R. I., (20) power generated by one municipal service is used by a second. The refuse incinerator is located in close proximity to the sewage-disposal plant. The incinerator burns a mixture of 35 per cent rubbish and 65 per cent garbage, which has an average heating value of 3600 Btu per lb as fired. Two waste-heat boilers each rated at 23,700 lb per hr, generate steam at 225 psig. Power is obtained from a 1250-kw turbogenerator. This power is used to operate the equipment in the

THE PROPOSED CYCLE

The proposed gas-turbine cycle is represented in the flow diagram Fig. 2. Air enters the compressor (A) at 1. The compression is in two stages, with intercooling (B). The air then enters the heat exchanger (C) where the temperature is increased. These operations can be followed in the T-S diagram Fig. 3. Normally, the temperature 5′ leaving the heat exchanger is high enough for use at the turbine inlet. If, for any reason, this should not be realized, an auxiliary fuel system is used to make good this deficiency. Through a suitable arrangement of valves, the compressed air may be routed through the combustor (E) where auxiliary oil fuel is burned.

Work is done in the turbine (D) supplying the power for compressing the air and for the generation of electrical energy.

The air leaving the turbine is still at a relatively high temperature. In some gas-turbine cycles, a regenerator is installed after the turbine to utilize this high-temperature gas. Here, however, the exit gases are sent from the turbine to a furnace (F) to serve as preheated air. The valve 8 makes it possible to bypass heated air to the atmosphere and serves as a control device for the furnace. Cold air may be introduced at 9 and further secondary air at 10. The hot products of combustion are sent from the furnace to the heat exchanger where heat is given up for the gas-turbine cycle. From 12 the spent gas is moved to the drier or by-passed to the stack.

The moist fuel is introduced into the drier (G) through a suitable hopper device; the moisture content is reduced as the fuel mixes with products of combustion from the furnace.

It is generally conceded that incinerator temperatures should exceed 1400 F, if the odoriferous substances are to be eliminated. Present gas temperatures from 1800 F to 2500 F are reported (20). The heart of the cycle is the heat exchanger and competent

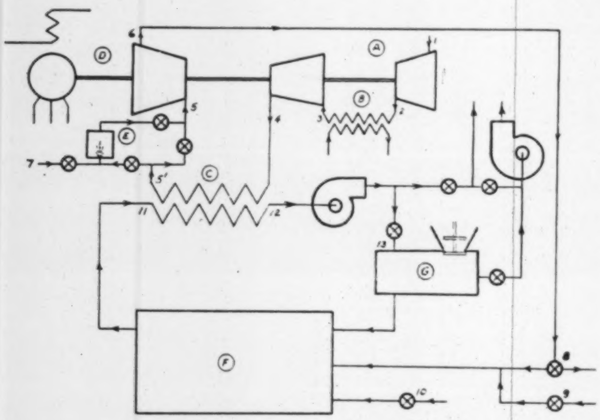


FIG. 2 FLOW DIAGRAM OF PROPOSED GAS-TURBINE CYCLE

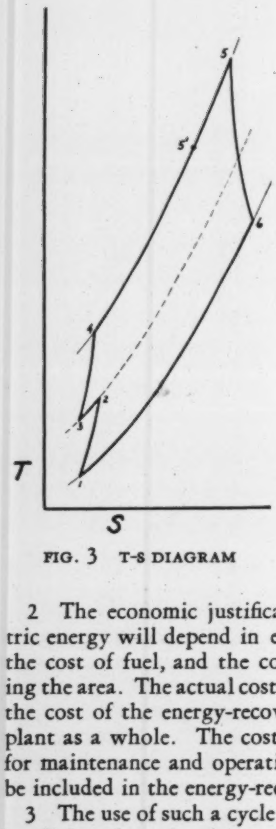


FIG. 3 T-S DIAGRAM

design here is essential. The present state of the art would indicate that a straight tubular heater would do best in such an installation, as cleaning will be an important consideration. In addition to the usual heat-transfer and pressure-drop calculations, the drying and burning of the moist fuel must be considered. This obviates any general solution, each individual case calling for special treatment.

CONCLUSIONS

1 Experience with steam-generating equipment has shown the practicability of using wood waste, bagasse, and refuse as fuel, and it is probable that similar use will someday be made of pulp-mill waste.

2 The economic justification for producing steam or electric energy will depend in each case upon local requirements, the cost of fuel, and the co-operation of the utilities supplying the area. The actual cost of such power should be based upon the cost of the energy-recovery equipment, and not upon the plant as a whole. The cost of the auxiliary fuel and the cost for maintenance and operation of the generating units should be included in the energy-recovery charges.

3 The use of such a cycle would be especially appropriate in localities where the city generates power for the use of municipal agencies, or for the community as a whole. The self-liquidating nature of such an investment should prove an attractive element.

4 Advances in metallurgy will make possible greater efficiencies in the gas-turbine cycle as the throttle temperatures are raised. Standardization of gas turbines should make the energy-recovery-equipment investment lower.

APPENDIX

An indication of the performance of the cycle can be gained from a full-load heat balance on a plant designed to generate 1000 kw from wood waste, as follows:

Compression in two, 84 per cent efficient, stages with equal work division, and a temperature reduction of 50 deg F in the intercooler. Inlet-air conditions 14.7 psia, 80 F, dry; over-all ratio of pressures 5 (24); throttle temperature 1000 F; heat-exchanger pressure drop 1 psi, 55 per cent effective; turbine efficiency 86 per cent, generator efficiency 97 per cent. The gas-turbine and compressor-plant calculations are based on Navy Gas Charts (25). Heating value of fuel = 8000 Btu per lb.

The following can be shown:

Net work = turbine work — compressor work = 111.90 — 88.27 = 23.63 Btu per lb.

Heat to cooling water = 12.06 Btu per lb.

Thermal efficiency based upon heat supplied in heat exchanger = 15.4 per cent

Internal power produced = 1042.2 kw

Air to be handled by compressor = 34,100 cfm

Fuel rate = 5400 lb per hr

Air requirements are more than met for the drier and combustion chamber.

BIBLIOGRAPHY

1 "Refuse Collection and Disposal," by Abel Wolman, Gustav Requart and H. W. Woodward, Report to the Mayor and City Council of the City of Baltimore, Nov. 24, 1944.

2 "Atlanta's New Incinerator—Steam From Waste," by H. J. Cates, *Southern Power and Industry*, vol. 60, Aug., 1942, p. 50.

3 "Putting Incinerator Operation on a Paying Basis," by H. J. Cates and R. G. Hicklin, *American City*, vol. 57, July, 1942, pp. 67–69.

4 "Gas Turbine System," Woodward and Potter, U. S. Letters Patent, No. 2,401,285.

5 "Putting Wood Wastes to Use," by C. A. Basore, *Chemical and Metallurgical Engineering*, vol. 38, Sept., 1931, p. 543.

6 "Economical Combustion of Bagasse," by A. F. Shillington, *International Sugar Journal*, vol. 41, July, 1939, p. 258.

7 "Utilization of Surplus Bagasse in Java," by J. Eigenhuis, *International Sugar Journal*, vol. 38, July, 1936, p. 263.

8 "Bagasse as National Fuel in Cuba," by J. L. Plana, *International Sugar Journal*, vol. 46, Sept., 1944, pp. 235–237.

9 "Storage of Bagasse," by G. H. Rounthwaite, *Combustion*, vol. 13, May, 1942, p. 45.

10 "Burning Paper Mill Waste From Sulphite Mill," by G. Keeth, Trans. A.S.M.E., vol. 61, 1939, p. 679.

11 "Collection and Disposal of Garbage and Refuse in American Cities," a survey by the editors of *Public Works*, vol. 71, June, 1940, pp. 9–11 and 31–34.

12 "Modern Garbage Disposal—Incinerator or Burial?" by D. P. Tynan, *American City*, vol. 54, June, 1939, p. 100.

13 "Bagasse Furnaces," by E. W. Kerr, Trans. A.S.M.E., vol. 61, 1939, p. 685.

14 "Notes on Combustion of Bagasse," by J. Eigenhuis, *International Sugar Journal*, vol. 39, Dec., 1937, p. 474.

15 "Modern Trends in Use of Wood Waste for Fuel," by H. S. Bastian, *Combustion*, vol. 4, March, 1933, p. 13.

16 "Danish Methods in Refuse Destruction," by H. W. Pye, *Municipal Sanitation*, vol. 5, Dec., 1934, p. 404.

17 "Incinerators—Municipal, Industrial, and Domestic," by H. S. Hersey, Trans. A.S.M.E., vol. 59, 1937, pp. 267–278.

18 "Incineration of Municipal Refuse," by H. W. Taylor, *Municipal Sanitation*, vol. 9, Feb., 1938, pp. 130–132.

19 "The ABC's of Wood Fuel," by R. B. Boals, *Power*, vol. 89, March, 1945, pp. 152–154.

20 "Power From Incinerator Used by Sewage Plant," by P. E. Holton, *Public Works*, vol. 72, Sept., 1941, p. 28.

21 "Paris Refuse Incinerator Generates By-Product Power," by J. Colon, *Power*, vol. 74, July, 1931, p. 55.

22 "Operating Experience With the Gas Turbine," by A. E. Pew, Jr., MECHANICAL ENGINEERING, vol. 67, 1945, p. 594.

23 "Mechanical Engineers' Handbook," by L. S. Marks, fourth edition, McGraw-Hill Book Company, Inc., New York, N. Y., 1944.

24 "The Gas Turbine," by J. T. Rettaliata, *Current Trends*, 1942, p. 18.

25 "Gas Turbine Gas Charts," Research Memorandum No. 6-44-Navships 250-330-6, Bureau of Ships, Navy Department.

TRENDS *in* SOLID-FUEL RESEARCH

By HAROLD J. ROSE[1]

BITUMINOUS COAL RESEARCH, INC., PITTSBURGH, PA. MEMBER A.S.M.E.

THE world has spent more of its mineral wealth in the last 40 years than in all preceding history. Production has been particularly great in the United States, so that we are already a "have-not" nation, or are rapidly becoming one, with respect to many important minerals.

The outstanding bright spot in this very serious situation is our enormous coal supply. In fact, we have about one half of the world's known reserves. Coal is this country's most important mineral resource and it will continue to be the foundation of our expanding industrial production.

Technical developments have made it possible to produce from coal almost any types of solid, liquid, or gaseous fuels, or synthetic chemical products, that are desired. Our coal resources are so enormous that they can supply all the United States requirements for heat, light, power, transportation, the smelting of metals, all liquid and gaseous fuels, and most synthetic chemicals for more than 1000 years at the present rate of consumption, with allowance for mining losses and conversion efficiencies!

Contrast with this the fact that our proved reserves of petroleum and natural gas combined, would last only $8^{1}/_{2}$ years if they could be produced and used fast enough to supply their present markets and to take over all present coal uses at the same Btu efficiency. The foregoing figures are based on a recent paper by A. C. Fieldner (1)[2] of the U. S. Bureau of Mines.

It is therefore plain that coal must soon begin to take over some of the fuel requirements now supplied by petroleum and natural gas. This is causing a great increase in the support of coal research by federal and state governments, by the petroleum, chemical, and gas industries, as well as by the coal industry itself, and by equipment manufacturers.

It is estimated that expenditures on research and engineering development work related to coal, total at least $15,000,000 a year in this country at the present time. This is probably a higher estimate than is generally reported, but it is believed to be reasonably reliable and conservative. Coal-research activities are constantly expanding to meet the increasing demands which will be made on coal to maintain the industrial supremacy of the United States and our high standard of living. Some of the trends in coal research will be mentioned.

COAL MINING

Coal has usually had the advantage of being considerably cheaper than other fuels. About two thirds of the cost of coal at the mine is labor. Wages in coal mining have increased at a greater rate than in other industries, until they are higher today than in the former high-paying industries. For example, coal miners' wages on either a weekly or monthly basis are now higher than wages in the iron and steel industry, or even the automobile industry.

As a result, the cost differential has decreased between coal and competitive fuels which need less labor to produce.

Increased mechanization is one answer to high labor costs. Mining-equipment manufacturers have made great improvements in cutting and loading machines, underground transportation, etc. However, most of the improvements have been in machines to handle individual phases of a sequence of intermittent operations which have to be co-ordinated underground.

What is needed are machines which will cut and load coal continuously. A great deal of practical work has been done on this problem by coal producers and machine designers in this country. Some novel designs are undergoing development and trial. However, none is commercially established and in general use as yet.

The situation is becoming urgent, and the industry's national research agency, Bituminous Coal Research, Inc., is organizing a major, separately financed project, to hasten the development of continuous mining and loading methods for underground use. Plans were completed only a short time ago, but already more than half of the funds for the initial goal have been subscribed. It is planned to establish a special Mining Development Committee under BCR, with a separate Director of Development, following the pattern that is working so well for BCR's Locomotive Development Committee.

Questions are often asked about the coal planer (2) developed in Germany during the war. In 1945, I saw this device in operation in a mine which won a Nazi cash prize for record wartime production with the coal planer. A cutting blade pulled by wire rope, cut out the bottom third of a friable coal seam to a depth of 12 in. and diverted it onto a moving conveyer which paralleled the path of the planer. The overhanging coal was aided by roof pressure to break away without much manual help, and it also fell on the conveyer. A trailing shuttle automatically forced the coal planer and conveyer over to the new position. Thus, in one continuous operation coal was cut from the solid, loaded on a conveyer, and the device was moved over against the new coal face.

This method was used to produce coal on faces about 670 ft long. Longwall operation is very common abroad, but is little used in this country, owing to different conditions. American mining men doubt that the coal planer will find much use here. While it broke production records in Germany, those records were no better, if as good, as the production in some American mines using the conventional cycle of cutting, drilling, shooting, loading, and hauling. Other types of continuous-mining equipment are expected to be better adapted to American conditions.

UNDERGROUND GASIFICATION

An entirely different method is also under study for circumventing the high labor cost of mining coal. This is underground gasification, in which a coal seam is set on fire, and supplied with air and steam for the purpose of producing gas usable for power or chemical purposes.

The idea was suggested decades ago, in several countries, but it seems to have been tried out first in Russia some years before the recent war. Technical information from these earlier tests was incomplete and not particularly encouraging. Little authentic information has been made available on later

---

[1] Vice-President and Director of Research.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Address presented at the Fuels General Luncheon, June 18, 1947, Semi-Annual Meeting, Chicago, Ill., of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Russian experiments and this has led many to doubt that they have made much practical progress. However, some engineers believe that Russia is making limited industrial use of underground gasification at present.

In Belgium the government and leading industries have been sponsoring a project on underground gasification for several years. Large-scale practical trials have not yet been made underground. It is understood that experiments will be made in England under government sponsorship. There are persistent unconfirmed rumors that a large American chemical company has been gasifying coal underground for several months.

Since detailed experimental results are not available from any of the sources mentioned, it is gratifying that fully documented results of a recent underground gasification test at Gorgas, Ala., are being made available. The Alabama Power Company took the initiative in organizing this test and provided the site and the labor for development work and operation. The U. S. Bureau of Mines co-operated by furnishing technical men and instruments and collecting data. The sponsors were most generous in welcoming technical visitors at all stages of the work and in discussing the results obtained. A comprehensive report is being completed by the bureau and should be available soon.

The sponsors feel that the results of this exploratory test at Gorgas were more favorable than had been expected. A few hundred tons of coal were consumed and burned away clean without loss in unburned pockets. Under the conditions existing in this particular test, the roof did not crack and fall. Instead it softened and swelled, thus expanding or flowing into the space formerly occupied by coal. This supported the overlying strata and also kept the current of air and steam against the reactive face of the coal seam.

The tests were handicapped by an inadequate blower, which limited the experiment to a rather low burning rate. The average quality of gas made and thermal efficiency of gasification were not very impressive in this exploratory test but may be considerably improved by more favorable conditions. Gas of a considerable range in heating value was made under various selected conditions. This test was made on a small isolated area of coal. Mining engineers are particularly concerned with the problem of confining underground fires to definite boundaries.

It is agreed that additional larger-scale tests at higher gasification rates are necessary before the technical possibilities can be evaluated. Economic studies need to be made to determine whether, by assuming rather favorable conditions based on existing knowledge, it appears that underground gasification can compete with more conventional methods of deriving energy from coal. A long period of practical large-scale development will doubtless be required to determine the possibilities and limitations of underground gasification.

COAL PREPARATION

Development work is active on new and improved methods for sizing, cleaning, and drying coal. The percentage of coal that is mechanically cleaned has increased every year for the past 20 years. Space does not permit detailed reference to the various ingenious methods which are being used or tested on a large scale for cleaning coal in heavy-gravity media, by froth flotation, electrostatic separation, etc.

The adaptability of coal to special purposes may be illustrated by methods for producing low-ash coal which were put into plant-scale operation in Germany under the stress of wartime shortages (3). Bituminous coal was cleaned down to 2 to 3 per cent ash for hydrogenation plants, to 0.5 to 0.7 per cent ash for electrodes, and to as low as 0.05 per cent ash for high-purity electrodes. Individual plants had outputs of supercleaned coal up to several thousand tons per month, each. Froth flotation or extraction methods were used in the final stage of cleaning.

In one process, froth-floated coal containing 1.2 per cent ash was heated at the boiling temperature in a dilute solution of hydrochloric and hydrofluoric acids which reduced the ash to 0.5 per cent. In another process, a hot solution of caustic soda was used instead.

The most striking results in the separation of ash were obtained by the Pott-Broche process (4), in which coal was depolymerized and lightly hydrogenated while suspended in a solvent oil at about 770 F. The modified coal went into solution and was filtered away from the ash and other insolubles. After removing the solvent oil in a vacuum still, the product was a black, brittle, modified coal containing only 0.05 to 0.08 per cent ash. It was coked to produce an ultra-low-ash coke for the manufacture of high-purity aluminum. It sold for twice the price of pitch coke, which has several times as much ash. The plant was designed to produce about 2000 tons of pure coal per month but operations were interrupted and finally stopped by repeated bombings.

These processes for low-ash coal do not indicate any unique inventive ability of the Germans. They show, instead, that when necessity or economic conditions dictate, coal technologists can modify coal to most any extent that is necessary. Acid extraction of coal ash has long been known to American coal chemists, and has occasionally been used in the laboratory to prepare low-ash coal or coke. However, commercial use has not been justified here.

I was particularly interested personally in going through the Pott-Broche plant, because more than 20 years ago I was co-inventor of a process for dissolving bituminous coal in certain hot oils and separating the coal from the ash. Our patent application was earlier than that of Pott-Broche, but under American conditions the process has as yet been used only for special products. Economics have not justified its use for deashing coal to be used as fuel.

However, coal-research men cannot fail to be fascinated by the fact that it is possible to dissolve coal, to filter it from the ash, and to modify or react the coal while it is in solution. Another interesting fact is that the dissolved coal can be precipitated readily from solution, yielding exceeding small, rounded, low-ash particles only a few microns in size. This is a method of ultrafine coal pulverization which does not use mechanical grinding.

TRANSPORTATION

There is not much to report on new methods of transporting coal from the mines to consumers. The railroads are still the chief means of coal transportation, and solid-fuel shipments exceed in tonnage any other commodity or natural group of commodities handled by rail. For example, the freight tonnage of coal and coke is twice as great as the combined tonnage of all agricultural, animal, and forest products. It is also greater than the tonnage of all shipments of manufactures and miscellaneous items.

Figures averaged over a period of years show that the railroads get about as much for hauling a ton of coal as the producers do for mining it. Such statistics explain why coal-originating railroads are actively co-operating with the coal industry in research to hold and increase the markets for coal.

The production in the future of synthetic liquid fuels from coal, of high-Btu pipe-line gas from coal, and the operation of gas-turbine electric plants at the mines, may be thought of as permitting alternative methods of transporting energy from coal.

RAILROAD LOCOMOTIVES

The largest single market for bituminous coal is as fuel for steam locomotives. However, the supremacy of coal for railroad use is currently being challenged by oil-burning locomotives of various types.

Many readers are familiar with the paper by Yellott and Kottcamp (5) describing the current status of the fast-moving development on coal-burning gas-turbine locomotives, which is being handled by BCR's Locomotive Development Committee.

The object is to develop coal-burning locomotives for high-speed service which can travel 1000 miles nonstop, at 100 mph, and burn a wide variety of coals smokelessly, at good efficiency without requiring water. Two gas-turbine power plants of about 4000 shp are on order, and contracts will be placed soon for suitable locomotive chassis. It is expected that both locomotives will be road-tested in 1948.

Modern steam locomotives of improved conventional design are giving outstanding results. New world records for coal-fired steam locomotives were made recently when six engines of the New York Central Railroad, averaged almost 22,000 miles per month each, for a period of 6 months. Individual engines made records exceeding 28,000 miles per month during the period. Large steam-turbine direct-drive and steam-turbine electric-drive locomotives have been built for leading railroads.

Bituminous Coal Research, Inc., is sponsoring research supported by coal producers, railroads, and manufacturers, on improvements in coal-handling, combustion efficiency, performance, and cleanliness of conventional steam locomotives. There are some 35,000 of these in use, and new improved models are being built.

POWER FROM COAL

It will be obvious to power engineers that the research and engineering work necessary to develop coal-burning gas-turbine locomotives should have far-reaching effects on other uses of coal. The work includes, for example, laboratory research, engineering design, and full-scale testing on such important projects as (*a*) a new method for pulverizing coal; (*b*) combustion of pulverized coal under pressure; (*c*) new equipment for efficient removal of fly ash from hot combustion gases; (*d*) efficient power generation without need for condensing water. The location of conventional steam-electric power plants is greatly restricted by the fact that 300 to 600 tons of condensing water are required for every ton of coal burned.

I have just returned from a western trip which revealed keen interest in coal-burning gas turbines there. The Rocky Mountain states have enormous deposits of coal, a growing need for power, a scarcity of good water in many areas, and a realization that their oil and gas supplies cannot meet the rapidly increasing demands. Many believe that coal-burning gas turbines (or possibly turbines operated by gas from underground gasification) will be an answer to mine-mouth power generation.

A Swiss turbine engineer has predicted coal-burning gas turbines producing 50,000 and even 100,000 kw per shaft (6). Using a closed cycle with $^1/_{10}$ to $^1/_5$ as much intercooling water as needed by a steam-turbine plant, he considers that thermal efficiencies from coal as high as 35 per cent or more are possible for large installations after a future period of development.

It is not necessary to review current trends in the development of power from coal. This is a field where equipment manufacturers and power-company engineers have long been doing outstanding work.

As a single example, the cyclone burner may be mentioned, which has been described in some detail in a previous paper (7).

Much needed attention is being given to the development of more highly automatic small boiler plants in the 30 to 300-hp range. Such plants are extremely numerous, and their labor problems focus attention on the need for units which will handle coal and ashes as automatically as possible.

SMOKE ABATEMENT

The Department of Smoke Inspection and Abatement in Chicago has long been active in applying overfire-air jets as a means of smoke abatement. Several years ago BCR sponsored systematic engineering research at Battelle Memorial Institute to improve the efficiency of such jets and to design silencers for the steam-air type.

The results have been given wide distribution and thousands of successful installations of modern air jets have been made. This information is being distributed nationally through articles in magazines, technical bulletins, talks and "clinics." Bituminous Coal Research, Inc., now has in press new or enlarged publications on the design and application of overfire jets for smoke abatement on stationary plants, locomotives, and steamships.

There is also great activity in the development of smokeless heating equipment for residences and small commercial uses.

ATOMIC ENERGY

The coal industry follows the topic of atomic power with interest but is not worried about its competitive aspects for a number of reasons which need not be listed here.

It is the opinion of one authority, who recently addressed this Society (8), that the first atomic plant producing appreciable amounts of electricity can be expected 3 to 6 years from now, and a larger-scale prototype plant, say, 10 years from now. He predicts that future commercial development of atomic energy will of necessity come in a gradual and orderly way. Commercial production in quantities representing a substantial fraction of present U. S. power production probably will not be reached before 20 to 50 years from now.

On the basis of present knowledge, atomic power, if and when it does reach the competitive stage, is not expected to replace coal or any other fuel. Rather it will supplement them, and merely supply a share of the world's constantly increasing demand for energy.

GASIFICATION AND CARBONIZATION

Gasification and chemical synthesis are among the most intensely active fields of coal technology. Millions of dollars are being spent annually in this field by Government and industry.

Several new techniques are revolutionizing thinking and engineering design. In a recent paper, A. D. Singh (9) describes the fluidized-suspension method for carbonizing coal. This method can also be used for gasification. It offers exceptional possibilities for close temperature control in the processing of large tonnages of coal. Another method is the gasification of low-rank fuels under pressure to produce a methane-enriched water gas. This and some other processes involving cheap oxygen, would open up new possibilities in gasification.

In England, gas-industry research has made some remarkable discoveries on the reactions of hot hydrogen with solid coal at high pressures. The results are of interest from both gasification and carbonization aspects and the unusual type of coke.

During the past few years, around 100,000,000 tons of coal have been carbonized annually in the United States. The tonnage varies with industrial activity and averages 17 per cent of the total bituminous-coal production. It is mostly carbonized in by-product ovens. Beehive coke ovens again proved useful in meeting peak war demands and produced about one eighth of the total coke in 1942 and 1943.

Medium- and low-temperature carbonization is a minor factor statistically, since such use consumed less than 0.4 per cent of the coal carbonized in 1945. However, it is receiving further consideration for producing smokeless domestic fuel, and for modifying a portion of the high-volatile coal used at certain by-product coke plants. A large addition to the Disco plant near Pittsburgh is expected to more than double the country's consumption of coal for low-temperature carbonization.

Research continues on the production of new chemicals from the various primary products of coal carbonization.

LIQUID FUELS

The demand for liquid fuels now exceeds the wartime peak and is still increasing. I do not know any well-informed, responsible, technical man, whether in petroleum, geological, chemical, or government circles, who believes that the United States can long continue to meet the increasing demand for liquid fuel from U. S. petroleum or even western-hemisphere petroleum sources. In the case of another national emergency, the liquid-fuel problem would be immediate and acute.

National security lies in new sources of liquid fuel. Some gasoline will be produced synthetically from natural gas, and there are possibilities of obtaining rather expensive and hard-to-refine oil from oil shale. However, for the long pull, unquestionably we must depend upon liquid fuels from coal.

A leading oil company has just issued estimates in a publication (10) for its employees and stockholders, on the amounts of gasoline which could be brought into commercial production at various service-station prices. At prices up to 26 cents per gallon, which is not far from present levels, they estimate that 10 billion barrels of gasoline can be expected from domestic proved reserves of petroleum, 3 billion barrels from available natural gas, less than 1 billion barrels from tar sands, and 300 billion barrels from coal. At service-station gasoline prices of 26 to 31 cents per gallon, they estimate that about another billion barrels of gasoline would be available from tar sands, 16 billion barrels from oil shale, but about 3400 billion barrels from coal. Present estimates place our total domestic gasoline demand at 860 billion barrels in 1950, and it is expected to reach 1 billion barrels annually by about 1961.

Much interest was aroused by the recent announcement of a co-operative research by the Pittsburgh Consolidation Coal Company and the Standard Oil Development Company. This deals with pilot-plant-scale research on the carbonization and complete gasification of coal to produce a variety of products.

Expressed in Hollywood terms, the production of liquid fuels from coal should become a "supercolossal" industry. No doubt some readers have seen, as I have, huge German plants which were used to make synthetic gasoline. All of these German plants combined, produced only 29 billion barrels a year at the peak rate of wartime production (11). This is about 3 per cent of current United States demand for gasoline. If all of the gas now produced by the United States' manufactured-gas-utility industry, were converted into synthetic gasoline, it would supply only about 1 per cent of our gasoline demands.

These comparisons will show that a huge industrial development is in the making. The synthetic-fuel industry based on coal will create a corresponding demand for fuel technologists and engineers, as well as for materials and labor.

At present, industrial companies are concentrating chiefly on the Fischer-Tropsch type of synthesis, which uses carbon monoxide and hydrogen derived from coal, water, and air. The U. S. Bureau of Mines is working, in addition, on improvements in the coal-hydrogenation (Bergius) process. By improving the steps in this process, bureau engineers expect to double the typical thermal efficiency obtained in Germany, and to convert more than 50 per cent of the Btu in the total raw coal used into the form of liquid fuel.

HOUSE HEATING

Many research projects, on improved house heating with coal, are in progress by BCR and many others. These activities are mostly directed toward developing equipment for more convenient, clean, economical space heating. This is one of the very largest markets for coal but it is highly competitive.

Alternate de luxe methods of space heating include the use of manufactured gas derived from coal, and heat pumps driven by electricity generated from coal.

CONCLUSION

A research director has little peace of mind—things are changing too fast. For example, the element carbon was formerly considered to be a single species with an atomic weight of 12. Now there are five recognized atomic species.

Two of these, C^{12} and C^{13} are stable naturally occurring forms which make up carbon as it is ordinarily known. Then there are three artificially produced radioactive varieties, C^{10}, C^{11}, and C^{14} with half lives of 8.8 sec, 21 min, and 1000 years, respectively. They emit beta rays (electrons) or positrons. Some of these are proving to be incredibly powerful research tools, not only for studying industrial reactions, but for unlocking the mysteries of life and death itself.

It is evident to every thinking person that scientific research, engineering development, and invention are remaking the world at a constantly accelerating rate. No one can know what the future will bring, yet it seems certain that coal will occupy an increasingly important and vital place in world economy.

The situation may be summed up as follows: The United States has nearly one half of the world's known coal supply. This can be chemically transformed into all of our solid-, liquid-, and gaseous-fuel requirements for heat, light, power, transportation, the smelting of metals, and chemical synthesis. There is enough coal to supply all of these needs for many centuries to come, after allowing for losses and conversion efficiencies. Our proved reserves of petroleum and natural gas total only 0.4 per cent of our coal reserves. Therefore, it seems certain that coal will be the basis of enormous synthetic chemical industries of the future. Fuel research based on coal can be the foundation of a thousand years of industrial greatness for this nation.

BIBLIOGRAPHY

1 "The National Fuel Reserves," by A. C. Fieldner, Mechanical Engineering, vol. 69, March, 1947, pp. 221–226 and 228.

2 "Design and Operation of the Coal Planer Ruhr District, Germany," by J. W. Buch, U. S. Bureau of Mines, Inf. Circ. 7377, Oct., 1946.

3 "Coal Preparation in Germany and the Netherlands," by H. F. Yancey and T. Frazer, Trans. American Institute of Mining and Metallurgical Engineers, vol. 168, Coal Division, 1946, pp. 272–285.

4 "Coal Extraction Plant of Ruhrol, G. m. b. H.," by H. H. Lowry and H. J. Rose, U. S. Department of Commerce, Office of Technical Services, Report PB 4323, 1945.

5 "Coal-Burning Gas-Turbine Power Plant," by J. I. Yellott and C. F. Kottcamp. Presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of The American Society of Mechanical Engineers.

6 "The Aerodynamic Turbine Compared with Steam- and Gas-Turbines," by C. Keller, *A Century of Turbines*, Escher-Wyss Engineering Works, Ltd., Zurich, Switzerland, pp. 20-41.

7 "The Horizontal Cyclone Burner," by A. E. Grunert, L. Skog, and L. S. Wilcoxson, *Electrical World*, vol. 126, Dec. 21, 1946, pp. 69–71.

8 "Atomic-Power Engineering—Some Design Problems," by Bruce R. Prentice, Mechanical Engineering, September, 1947, pp. 721–727.

9 "Fluid Devolatilization of Coal for Power-Plant Practice," by A. D. Singh, presented at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of The American Society of Mechanical Engineers.

10 "Synthetic Gasoline," *The Lamp*, published by the Standard Oil Company of New Jersey, New York, N. Y., March, 1947, pp. 6–11.

11 "German Developments in the Production of Synthetic Liquid Fuels," by A. R. Powell, Trans. American Institute of Mining and Metallurgical Engineers, vol. 168, Coal Division, 1946, pp. 323–328.

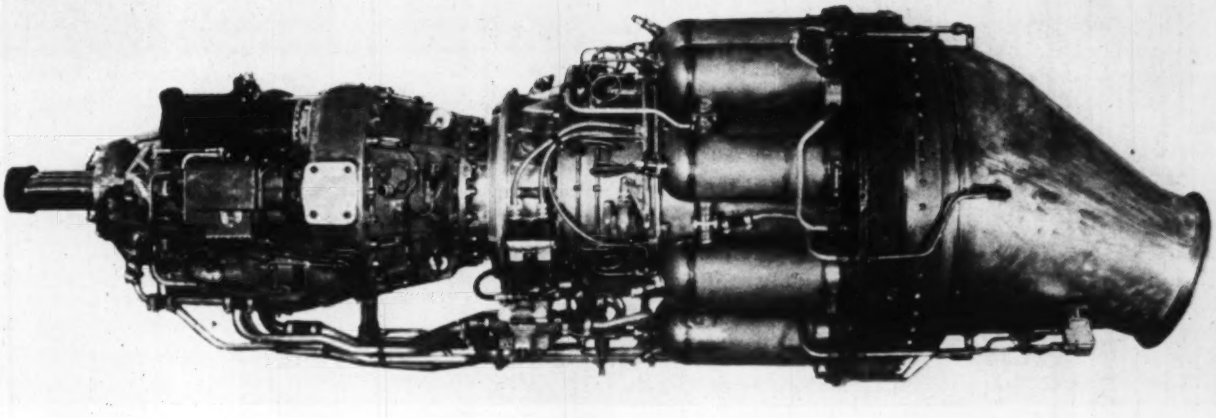


FIG. 1 GENERAL VIEW OF AIRCRAFT GAS TURBINE

An AIRCRAFT GAS TURBINE *for* PROPELLER DRIVE

By ALAN HOWARD and C. J. WALKER

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y. MEMBERS A.S.M.E.

INTRODUCTION

FOR many years the authors' company, with continuing encouragement from the Army Air Forces, studied the gas turbine as the main propulsion for aircraft as well as for other applications. It was understood that an order would be placed by the Army for such a power plant whenever it was agreed that technical advances would permit reasonable chances of success.

In 1941 fundamental combustion development for gas turbines was undertaken. This led to the invention of a simple all-metal type of combustor in which the liners were perforated cylinders closed at one end and which avoided the use of stub tubes extending into the combustion zone. The heat release was exceedingly high, and it appeared that the required fuel could be burned in a sufficiently small volume for aircraft applications.

Prior to this time, the axial-flow compressor had been studied and analyzed extensively and was believed to be very promising. None had been built by the authors' company, however, although test compressors were under construction.

The art of producing high-temperature alloy for turbine parts was advancing rapidly with major contributions being made within the authors' company, and considerable further improvement was anticipated.

Because of these encouraging factors, further extensive studies of aircraft-power-plant design were undertaken, partly under the sponsorship of the N.A.C.A. Committee on Jet Propulsion. These studies and designs looked quite favorable and the Army Air Forces were informed that there was a reasonable chance of developing a very useful unit.

Thus, late in 1941, shortly before Pearl Harbor, an order was placed for the design, construction, and test of the first aircraft gas turbine for propeller drive. The specified rating was 1200 hp at 500 mph at 25,000 ft. No other specifications were given, since at that time the general characteristics and possibilities were little known. This order was placed by the Army through Col. D. J. Keirn, who sponsored the development from the beginning and has been exceedingly helpful with his suggestions and his understanding of the various problems and difficulties.

Many additional studies were made to determine the optimum design, including considerations of fuel weight at the specified speed and altitude. These analyses showed the effect of designing with various turbine-inlet temperatures, jet velocities, pressure ratios, ram efficiencies, and with several arrangements of turbines, including separate drives for compressor and propeller. The use of a regenerator was considered, as were multistage turbines, and centrifugal compressors. Based on these studies, the power plant, then designated General Electric Type TG-100,[1] was decided upon.

It was recognized to be desirable to have tests on all components before proceeding with a complete power plant. However, waiting for such tests would have meant considerable delays. Consequently, the complete power plant was designed and built without tests being conducted on the components except the combustors and fuel nozzles.

The power plant was designed on the assumption that there would be continuing improvements in high-temperature metallurgy so that the turbine design temperatures and stresses were near the limit of feasibility with the then available materials.

Designs were completed in 1941 and construction of an

Contributed by the Aviation Division for presentation at the Annual Meeting, Atlantic City, N. J., December 1-5, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] Now known as the General Electric "Propjet" and in Army designation as XT-31.

engine was undertaken in 1942. Since that time, many have been built incorporating various improvements. Test runs totaling about 1360 hr of fired time have been made in several propeller test stands and dynamometer test stands. In addition, about 65 flights have been completed. Fifty of these were in the Consolidated Vultee XP-81 airplane, which was flown with the TG-100 in December, 1945. This airplane also carries an I-40 jet engine as an assist unit, which is used only when maximum performance is required. The remaining flights were made in the Ryan XF2R-1, which carries an I-16 jet engine as an assist unit. The flights, many to altitudes well above 30,000 ft, have been generally successful and there have been no power failures in flight. Some testing has been accomplished under high-altitude flight conditions in the N.A.C.A. altitude wind tunnel at Cleveland, Ohio.

When the power plant was first run, it was found that the performance was considerably better than the somewhat conservative original estimates. Therefore the "expected" military rating was increased 67 per cent to about 2000 "equivalent" shp at 500 mph, 25,000 ft including the jet effect. This value was believed to be attainable with a moderate development, and was expected to be reached about the time planes designed for the unit were produced. It was anticipated that the first several units might not quite meet the new expected performance.

With this anticipated rating, the fuel rate and weight of the power plant compare favorably with a conventional engine, and many studies show material gains in plane performance when the propjet is used.

During the development, many difficulties have been encountered and most of these have been overcome. The progress made to date is encouraging and it is confidently expected that this power plant will assume an important role in aircraft propulsion.

Publication of the present paper has been delayed because of military secrecy restrictions which have been removed only recently. Therefore it should be recognized that much of the design and test work here described was done considerably before that presented in many papers already published on gas turbines. Little of the general information now available was available at the time the initial work was done.

GENERAL FEATURES

A general view of the unit is shown in Fig. 1 and the general characteristics are given in Table 1. Rammed air enters the 14-stage compressor, is heated in the combustor, expands completely in the turbine, and is discharged at high velocity through the tail pipe. This high-velocity discharge normally contributes about 20 per cent of the net thrust, after subtracting the drag of the incoming air.

The unit runs at 13,000 rpm and drives the propeller at 1145 rpm through the double-reduction planetary gear. The expected take-off (standstill) rating is approximately 2400 hp, including the effect of the jet thrust. The rating at 500 mph and 25,000 ft is 2050 equivalent shp including the effect of the net jet thrust. The fuel rate under this condition is expected to be about 0.51 lb per shp, including the equivalent of the jet. There is no cooling drag (except for lube oil) to be subtracted. The complete power plant, including the reduction gear and all accessories, weighs 1975 lb, or less than 1 lb per hp.

The fuel system is designed to operate on either kerosene or gasoline without alteration of any kind. While kerosene has been used for most of the testing and flight time, gasoline has been used for both ground runs and flights without significant difference.

TABLE 1 MAJOR DIMENSIONS AND DETAILS OF PROPJET ENGINE

Dry weight including gear and accessories, lb	1975
Over-all length, in.	113
Maximum diameter, in.	37
Compressor type	Axial flow
Compressor stages, number	14
Compressor pressure ratio at 474 R inlet temp	6/1
Compressor speed, rpm	3000
Compressor blade-tip diameter, in.	$16^1/_2$
Compressor blade-tip velocity, fps	936
Compressor air flow (at sea-level standstill), lb per sec.	22
Turbine stages	1
Turbine pitch diameter, in.	26
Turbine speed, rpm	13000
Turbine pitch line velocity, fps	1475
Combustion chambers, number	9
Combustion maximum temperature, deg F	1900
Combustion continuous temperature, deg F	1750
Jet diameter	14
Reduction gear, type	Planetary
Reduction-gear stages	2
Reduction-gear ratio	11.35
Intermediate-shaft speed, rpm	2933
Propeller-shaft speed, rpm	1145
Propeller-shaft spline, no.	50
Accessory drive pads	6
Lubricating-oil flow, gpm	25

The turbine-inlet temperature at military rating is approximately 1900 F (2360 R). This is believed to be by far the highest design inlet temperature of any gas-turbine power plant This high temperature is feasible because of special design features of the turbine, described later.

In operation, the speed of the unit is held at the desired value by the constant-speed variable-pitch propeller. The load is controlled by the pilot's throttle lever, which in effect changes the amount of fuel burned. The control system is arranged to adjust the fuel automatically to maintain the power at an approximately constant fraction of rating for a given throttle setting regardless of changes in altitude or plane speed.

The unit is started by a battery-supplied electric motor rated 15 hp. This brings the unit to about 13 per cent speed where the fuel and ignition are turned on. The plant then accelerates to about 35 per cent speed, when the starting motor is disengaged and the ignition is turned off. The complete starting time from cold standstill to full load is 2 to 3 min. Using a larger starting motor, recent starts have been made in less than 1 min.

The starting batteries and motor have proved to be marginal and part of the development is being directed toward obtaining greater starting powers. Furthermore, as discussed later, a modification of the turbine nozzle and bucket passages should be made to improve the high-speed flight performance. This will further increase the required starting power because of lower turbine efficiency under starting conditions.

As discussed in more detail under "Performance," the fuel rate of the plant is lowest at full power, although, under altitude-flight conditions, it does not increase materially down to half-load. In a conventional engine the best fuel economy is normally attained at less than half-load, while the full-power fuel rate is more than 50 per cent greater and is considerably higher than the expected fuel rate of the propjet.

This means that the propjet is very attractive for high-speed cruising at high fractions of power. Studies show it to be superior to present conventional engines in many such applications.

The power plant fits very well into the pointed nose construction required for high-speed aircraft, as well as into wing installations. It is hoped that removal of military restrictions will soon permit designers of such planes to describe them in more detail than has so far been possible.

DESCRIPTION OF COMPONENT PARTS

Compressor. The 14-stage axial-flow compressor is designed according to the well-known principles of vortex flow and has pressure rise in both stator and rotor. The design pressure ratio (excluding ram) under altitude conditions is 6 to 1, and the pressure ratio under factory test conditions is 5 to 1. The tip diameter of the rotor blades is $16^1/_2$ in. which at the rated speed of 13,000 rpm gives a tip velocity of 935 fps.

In general, the over-all performance of the compressor has proved to be better than originally anticipated in both efficiency and in apparent margin to pulsation. Efficiencies well above 80 per cent have been obtained, and no pulsation has been encountered, even with the relatively high pressure ratio, believed to be the highest of any single-shaft machine yet tested. No bleed-off valves are required for starting.

The general construction of the rotor is shown in Figs. 2 and 3. As will be seen, each wheel carries an overhung lip which is shrunk under a mating lip carried on the adjacent wheel. The rotor is assembled by shrinking the wheels on the shaft successively, starting with the last stage. As the shaft fits are shrunk, the rim fits simultaneously engage with a shrink. The overhung lip on each wheel acts as a stop to prevent the blades in an adjacent wheel from sliding out of the dovetail slots. Keys at the hub of each wheel provide the drive. The first six wheels are aluminum and the last eight are steel.

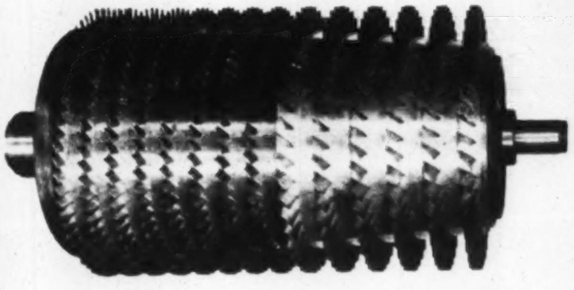


FIG. 2 COMPRESSOR ROTOR

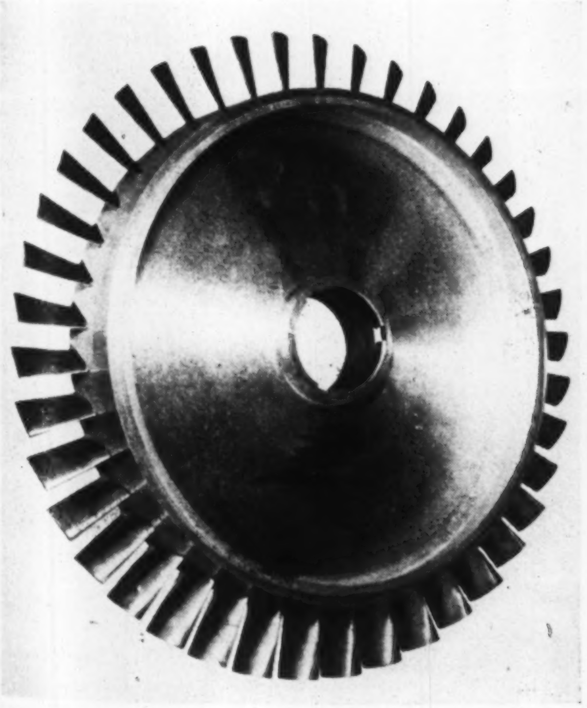


FIG. 3 COMPRESSOR WHEEL

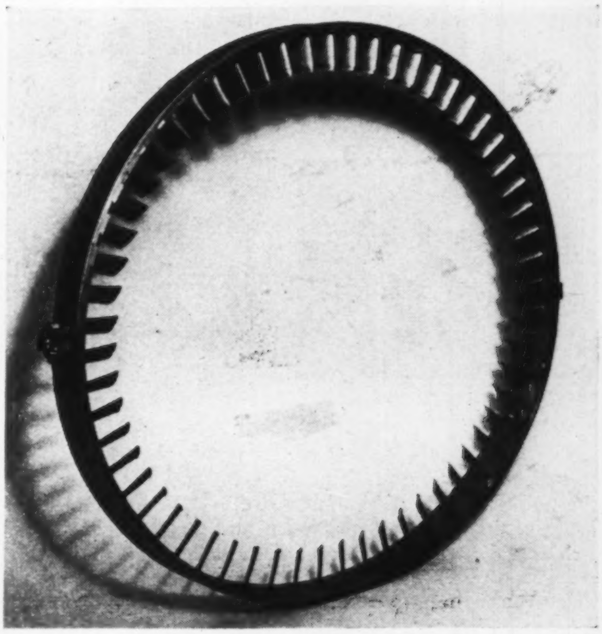


FIG. 4 COMPRESSOR STATOR-RING ASSEMBLY

The blades of both stator and rotor are steel alloy of about 13 per cent chrome. Both forged and cast blading have been used with success. The blades are held in dovetailed slots cut at the desired angle by end-milling. Each type of blade in the compressor is used for several stages with the length cut to suit.

The assembled rotor presents a smooth surface from which the blades appear to sprout. This unique separate wheel construction with nevertheless a smooth flow path permits high blade speeds not possible with the common hollow-drum construction because of stresses. There was a question as to whether the disk construction would require excessively large radial clearances because of transient temperature differentials, but no trouble attributed to this cause has been experienced.

The compressor stator is composed of alternate blade-carrying rings and spacer rings. The blade-carrying rings, Fig. 4, are split while the spacer rings are solid. The stator is assembled around the rotor by bolting the two halves of the stator rings together around the rotor and then sliding the spacer ring axially over the end of the rotor to engage the rabbet fits of the blade ring. The compressor-stator assembly is held together by a number of through-bolts. The rings of the first six stages are aluminum and the rest are steel.

This stacked construction has been thoroughly tested for deflections and stress under conditions corresponding to dives and spins and has been found to be exceedingly strong. No troubles have been encountered in operation. It is somewhat difficult to manufacture, and other constructions are being studied.

Combustion. A typical combustion chamber which was developed in the General Electric Research Laboratory comprises an outer casing, liner, and fuel nozzle as shown in Fig. 5. This simple and satisfactory form of combustor resulted from the

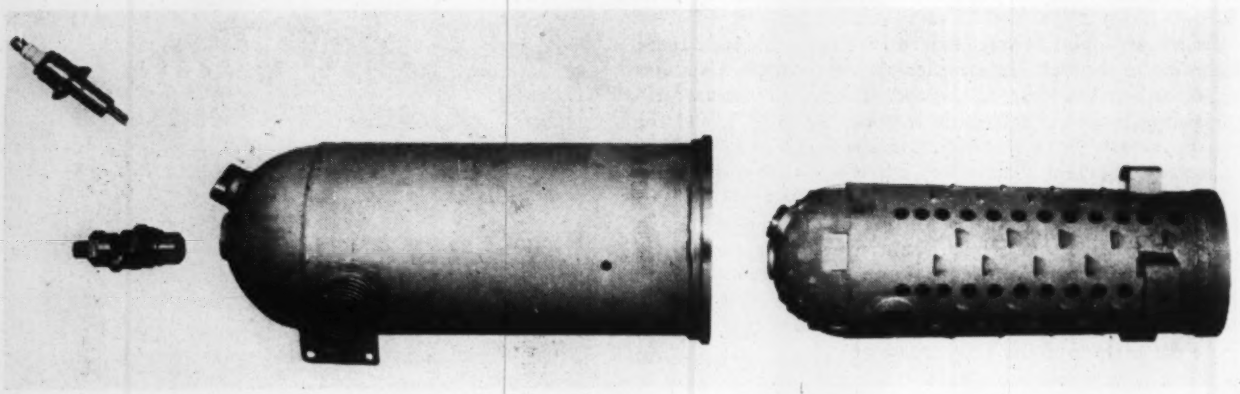


FIG. 5 COMBUSTION CHAMBER, LINER, FUEL NOZZLE, AND SPARK PLUG

afore-mentioned investigation of the fundamentals of combustion, which is still continuing actively. The inner liner consists of a simple cylinder with a hemispherical end dome and with round holes and slotted louvers punched in it. The arrangement of the round punched holes greatly affects the performance; literally, hundreds of different tests have been made to determine the optimum arrangement. This general type of combustor has been adopted for all General Electric gas turbines, and the stub tubes previously used in certain foreign combustion chambers have largely disappeared since this type of combustor was disclosed by the authors' colleagues to our friends abroad.

Exceedingly high rates of heat release are obtained in these combustors. Under maximum load at sea level standstill, the heat release is 28,000,000 Btu per hr per cu ft of liner volume. This is some 500 times the heat release in conventional boiler practice and is more than the full-power average heat release per cu ft of conventional reciprocating-engine cylinder volume.

Besides giving complete combustion with reasonably cool liners and low pressure drop, the combustors must produce a uniform temperature distribution, must ignite readily, and must not accumulate objectionable carbon deposits over a very wide range of operating conditions. The present combustors meet these conditions quite satisfactorily, although some work remains to be done on the elimination of carbon deposition under long-continued light-load operation. The liner life is normally between 150 and 200 hr on a factory-type test cycle. The life under flight conditions is somewhat less.

Fuel Nozzles. The satisfactory characteristics of the combustion depend upon the fuel nozzles as well as upon the combustor itself. Two types of vortex spray nozzles have been used, one a "recirculating" type, and another a "duplex" variety, developed in the General Electric Research Laboratory, in which both small and large slots deliver fuel into the whirl chamber. The small slots alone are used for small flows, and the large and small slots in parallel for large flows. This latter type of fuel nozzle was adopted as giving the most satisfactory over-all characteristics. With it satisfactory combustion is maintained over a ratio of more than 20 to 1 in fuel consumption, and much greater ranges are possible with the duplex nozzle.

Simple pressure-atomizing nozzles were not considered satisfactory because of the very high pressures involved in attempting to get a range of flow as wide as 20 to 1. This would require fuel pressures varying from 800 lb to 2 lb. At such low pressures good atomization and uniform fuel distribution in the combustor are almost impossible to obtain. With the General Electric duplex fuel nozzle, the range of pressures is from 500 lb to 50 lb, and excellent atomization is obtained at all times.

A single spring-loaded metering device is used as a "flow divider" to proportion the flow properly between the large and small slots of all nozzles.

Turbine. This gas turbine is unusual in many respects. It operates continuously with an initial temperature of 1750 F, and for 15-min periods with 1900 F. At the rated (and also the maximum) speed of 13,000 rpm, it must operate efficiently with pressure ratios ranging from 4/1 to 8/1. At this speed, the pitch-line velocity of the single wheel is 1475 fps.

The turbine wheel is of a special construction. The turbine buckets are welded to the rim. About 1000 hr of operating experience has been obtained with these wheels, without failure

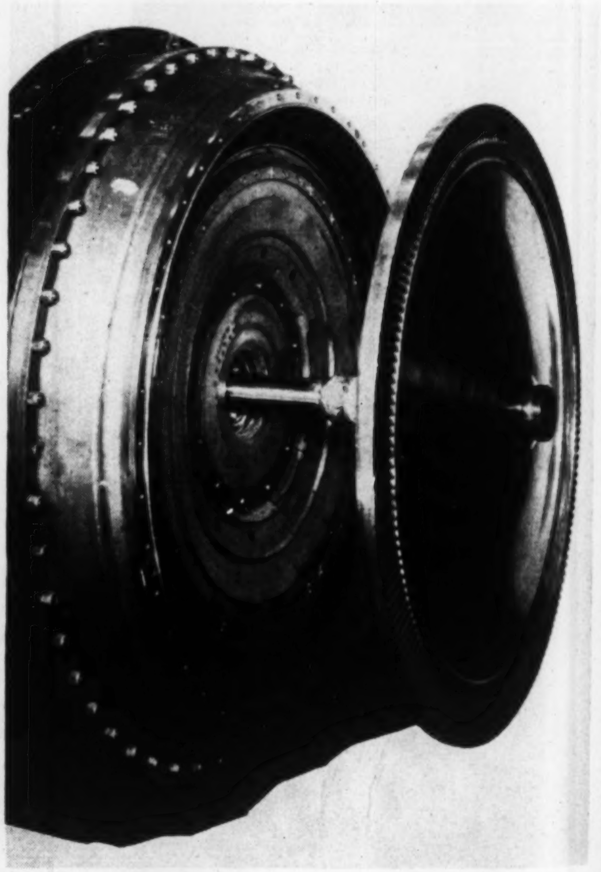


FIG. 6 TURBINE WHEEL AND NOZZLE

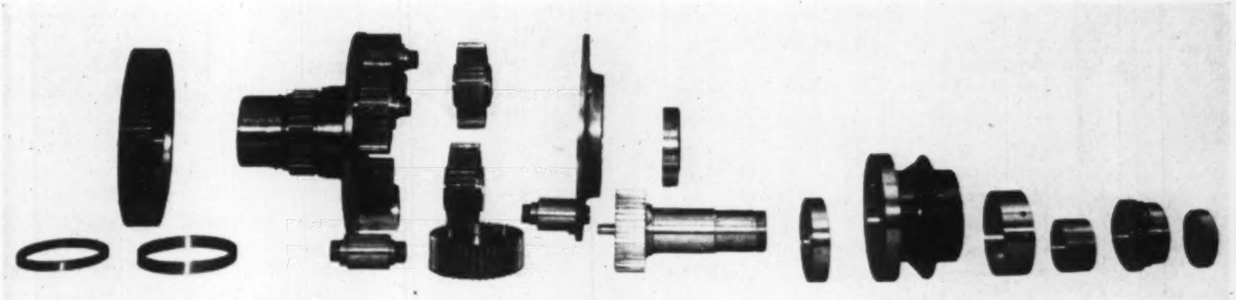


FIG. 7 ROTATING PARTS OF MAIN REDUCTION GEAR

of the welds. Both cast and forged turbine buckets, with integral individual bucket covers, are used. The turbine wheel is cooled on both sides by a small flow of air from the compressor.

The turbine nozzle, Fig. 6, is fabricated from cast segments with hollow partitions and integral sidewalls. The material is 25 per cent chrome and 20 per cent nickel. Part of the air from the compressor flows through the hollow internally finned partitions en route to the combustion chambers, and cools the nozzle.

The fabricated main frame structure supports the turbine nozzle and shell, the combustors, one end of the compressor, and the main bearing. This is a combined journal and tapered-land thrust bearing, which supports one end of the compressor rotor and the overhung turbine wheel. The exhaust cone is bolted to the nozzle shell. When the airplane designer locates a landing wheel or a pilot directly behind the engine, as he frequently does, the exhaust cone must be bent away from the axial direction in order that the tail pipe may clear these obstructions. A moderate angle, say, 20 deg, causes only 6 per cent reduction in axial jet thrust, but introduces some additional loss in the cone. The cone is equipped with a flow straightener to avoid a large pressure drop when the stream leaving the turbine wheel has a tangential component.

Main Reduction Gear. This double-reduction planetary gear has an over-all speed ratio of 11.35 so the propeller speed is 1145 rpm for 13,000 rpm of the main rotor. The intermediate shaft, Fig. 7, rotates at 2933 rpm. There are six low-speed and four high-speed planet gears. The low-speed ring gear is splined into the aluminum-alloy gear casing, while the high-speed ring gear is a loose fit and is equipped with six pistons and cylinders for measuring the transmitted torque.

The gear and planet bearings are lubricated with No. 1065 (about S.A.E. 30) oil which enters the hollow shaft near the propeller thrust bearing. The high-speed sun-gear shaft is supported by two ball bearings and is connected to the turbine shaft by a short hollow splined coupling. The pads for the driven accessories, and regulator, are clustered around the propeller shaft, and are all driven from a gear bolted to the low-speed planet cage.

This reduction gear is believed to be the first ever built for this high ratio and lightweight (about 0.25 lb per hp) at anything like comparable powers. The efficiency is quite high, about 98 per cent over-all, which corresponds to 99 per cent for a single reduction.

Accessories. A four-element positive-displacement pump supplies the 25-gpm lubricating-oil requirement, scavenges the gear and bearings and supplies 1200-psi oil for the torque-measuring system. The variable-displacement multiple-piston-type fuel pump operates with either kerosene or gasoline. The 15-hp starting motor is connected to the gear through an overrunning clutch and can supply torque up to 6000 rpm of the main rotor. The fuel regulator was designed and built by the authors' company. It uses lube oil as a hydraulic fluid, controls the fuel pressure, with full altitude compensation, and incorporates an overspeed governor and overtemperature protection controlled by thermally operated hydraulic elements mounted in the exhaust cone. The main generator is rated 400 amp at 28 volts.

Control. The power output of the engine is controlled by regulating the fuel flow, which is done by the fuel regulator in response to the position of the single throttle lever. This control system operates in conjunction with a constant-speed self-governing propeller. The pilot sets the propeller governor at the desired rpm, and adjusts the power output with the throttle lever. The altitude-sensitive fuel regulator automatically adjusts the fuel flow, in order to maintain the same percentage of rated output as altitude is changed.

The engine characteristics make it desirable to operate at the maximum permissible rpm, which leaves a minimum margin of overspeed for the propeller governor to work with. Conventional types of speed-sensitive propeller governors require too much speed change for their operation, and normal rates of pitch change are too slow for this engine. The propeller manufacturers are developing more suitable governors, and control systems in which speed control is the function of the fuel governor are being worked on. In the meantime, the presence of the overspeed governor in the fuel regulator makes it possible to operate satisfactorily with available propeller-governing systems.

The temperature-limiting thermal units in the exhaust cone operate in conjunction with the fuel regulator to cut back the flow of fuel when the exhaust temperature becomes excessive. At present, these operate to limit the full-load temperature and do not function during the starting cycle, but a control to permit automatic starting is being developed.

PERFORMANCE

Test Performance. As previously stated, the performance of the first unit was considerably better than the original rather conservative rating. The rating was then changed and a set of curves and data were published giving the performance anticipated. This anticipated or "expected" performance was what was estimated could be obtained by the time the units were in production and in combat service in airplanes. It was assumed that some improvement would be made, particularly in the turbine efficiency and in the reduction of some of the system pressure drops.

In the immediately succeeding machines, the turbine design was altered somewhat to improve the efficiency under starting conditions so as to reduce the required starting power. This objective was accomplished, but it was found that the turbine performance at full power has been compromised more than anticipated. The expected reduction in the pressure losses was

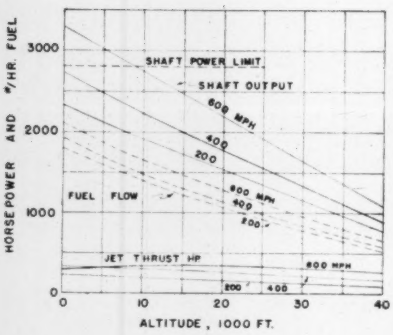


FIG. 8 PERFORMANCE AT MILITARY RATING

(Shaft power, jet power, and fuel consumption versus air speed and altitude; expected performance with 90 per cent ram efficiency.)

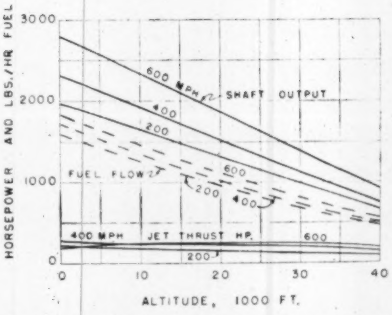


FIG. 9 PERFORMANCE AT NORMAL RATING

(Shaft power, jet power, and fuel consumption versus air speed and altitude; expected performance with 90 per cent ram efficiency.)

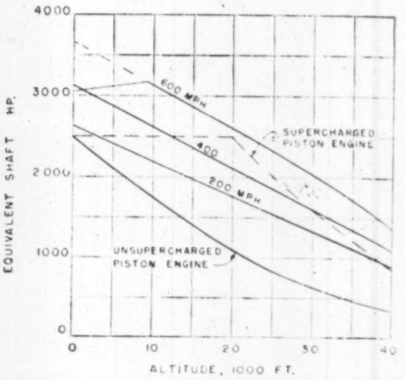


FIG. 10 EQUIVALENT SHAFT POWER VERSUS ALTITUDE AND AIR SPEED

(At military rating with 90 per cent ram efficiency. Equivalent shaft power includes jet power at 80 per cent propeller efficiency. Ram effect on piston engine disregarded.)

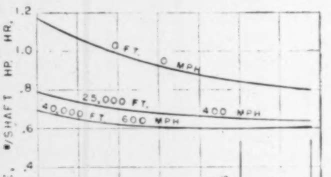


FIG. 11 PART-LOAD FUEL ECONOMY

(At various air speeds and altitudes. Jet power not included. For 90 per cent ram efficiency.)

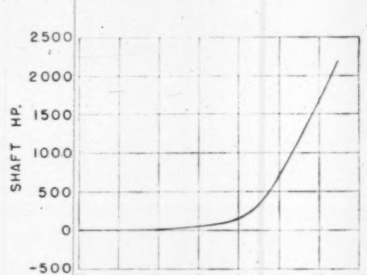


FIG. 12 SHAFT POWER VERSUS RPM

(At sea-level standstill, military rating.)

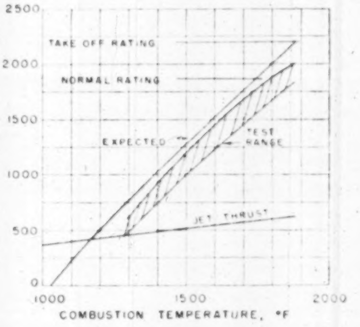


FIG. 13 EFFECT OF COMBUSTION TEMPERATURE

(On shaft power and jet thrust, for sea-level standstill operation at rated rpm, with ram pressure ratio = 1.0. Test results are from four engines.)

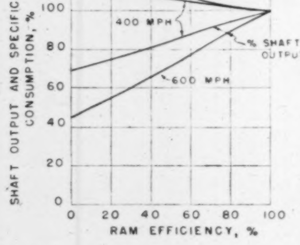


FIG. 14 EFFECT OF RAM EFFICIENCY ON SHAFT POWER AND SPECIFIC FUEL CONSUMPTION

(At 25,000 ft, military rating.)

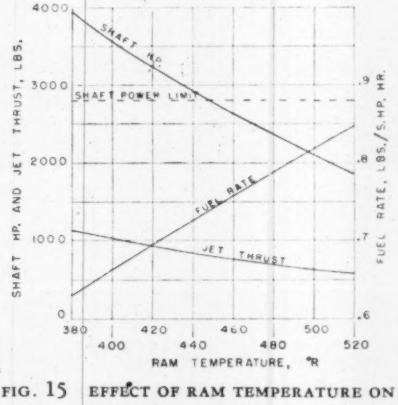


FIG. 15 EFFECT OF RAM TEMPERATURE ON SHAFT POWER, JET THRUST, AND FUEL RATE

(At sea-level standstill, for normal rating with ram pressure ratio = 1.0. Ram temperature is impact or total temperature at compressor inlet.)

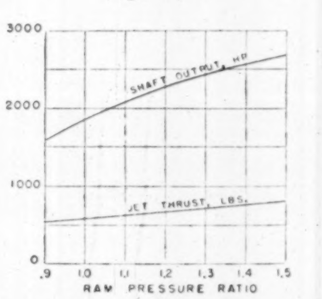


FIG. 16 EFFECT OF RAM PRESSURE RATIO ON SHAFT POWER AND JET THRUST

(At sea-level standstill, normal rating, with constant compressor inlet pressure.)

attained. However, the compressor performance was not quite as good as that of the first machine. This was finally traced to the less accurate blade shapes in the compressor of the succeeding machines, compared with the first machine which had received a great deal of attention and very careful hand work. Therefore it is to be expected that with continuing development the performance approximating the expected can be attained. In doing this, it is assumed that the starting-power requirements will be materially increased, since it is now believed unlikely that as broad a turbine efficiency characteristic can be attained as was at one time expected. This factor is one of the penalties inherent in a high-pressure-ratio single-stage design which does give lightweight and low bucket temperatures.

Expected Performance. The curves in Figs. 8 to 16, inclusive, are based upon the expected performance which was derived from the factory test performance of the first engine as just discussed. The relation of the actual high-altitude performance to this expected performance has not been obtained, since no accurate tests such as wind-tunnel tests have yet been run simulating these conditions.

General Characteristics. Figs. 8 and 9 show the general engine characteristics as functions of air speed and altitude, for military rating and for normal or maximum continuous rating. The power and fuel consumption of this propjet engine are greatly influenced by operating conditions although the output falls off much less rapidly with altitude than that of an unsupercharged conventional engine. Due to the combined effects of low temperature and high ram pressure, the military rating at 17,000 ft and 500 mph is equal to the military rating at take-off. The continuous rating at 40,000 ft and 500 mph is 1060 equivalent shp. (Equivalent shaft power is shaft power + net jet power at 80 per cent propeller efficiency, i.e., shaft power + 1.25 × jet power.)

Direct comparison with a piston engine is difficult, since the piston-engine performance at altitude is determined by the weight and complication of the supercharging equipment. However, compared to a piston engine supercharged to maintain sea-level power at 20,000 ft, and with equal take-off ratings, the XT-31 at 500 mph develops considerably more power at nearly all altitudes, as shown in Fig. 10. The specific fuel consumption improves at higher altitudes due to the reduction in compressor inlet temperature. Conversely, the performance is adversely affected by high ambient temperatures.

The fuel economy is best at maximum rating, but the increased specific fuel consumption at part loads is considerably influenced by air speed and altitude, as shown in Fig. 11. The XT-31 is designed to operate continuously at 85 per cent of the maximum short-time (15-min) rating, and, consequently, at nearly its best fuel economy.

The net shaft output of the propjet engine is the difference between turbine output and compressor input. At maximum rating, the ratio of compressor power to turbine power varies from 0.65 at sea-level standstill to 0.50 at 30,000 ft, 500 mph. It is apparent that any factor which directly influences turbine output will have from 2 to 3 times that effect on net shaft output, while a change in compressor work results in from 2 to 3 times as much change in net shaft output. At partial loads, these factors are still larger.

Table 2 lists the estimated effect of a number of losses on the shaft output and specific fuel consumption for sea-level standstill at maximum rating.

TABLE 2 ESTIMATED EFFECT OF LOSSES ON SHAFT OUTPUT AND FUEL CONSUMPTION

	Loss	Decrease in shaft output, per cent	Increase in spec. fuel consumption, per cent
1	Compressor-packing leakage	2.3	1.5
2	Cooling air from compressor	1.3	1.3
3	Balance-piston air from compressor	0.6	0.6
4	Leakage of hp air (estimated)	1.0	0.6
5	Pressure, loss, compressor outlet to turbine	9.3	9.3
6	Exhaust-cone loss	4.7	4.7
7	Incomplete combustion	0.0	1.0
8	Heat and radiation	0.0	0.4
9	Bearing, gear, and accessory losses	3.1	3.1
		22.3	22.5

The influences of these losses is quite large even at full power, but their percentage effect is variable with power output and also with such operating conditions as air speed and altitude. The effect of these losses on jet thrust is greatly different from their effect on shaft power.

The over-all performance of this propjet engine, as calculated, with due regard to the known losses, the proper turbine and compressor efficiencies, and the variable specific heats of air and the products of combustion, has been checked by sea-level dynamometer tests with reasonably good agreement.

Effect of Ambient and Operating Conditions. The following five primary variables influence the performance of this propjet engine: (1) Engine rpm; (2) combustion temperature; (3) ram pressure; (4) ram temperature; (5) ram pressure ratio. The interrelated effect of these variables on power output, fuel consumption, and jet thrust cannot be shown with a simple set of curves, so the primary effect of each will be discussed briefly.

Engine Rpm. The power output of this propjet falls off so rapidly as rpm is reduced that it is practically a constant-speed engine over most of the useful load range. Fig. 12 shows shaft power plotted against rpm for operation at sea-level standstill with constant exhaust temperature. The power output is negative up to 30 per cent speed, so a high-speed starter is required. In order to have some power available for acceleration, the idling speed is necessarily high (about 75 per cent.)

Detailed performance calculations indicate a best specific fuel consumption at maximum rpm for shaft powers greater than 50 per cent, for all conditions of flight. The rpm and therefore the engine rating are limited by the allowable wheel stresses.

A speed limit has been set and will not be exceeded until a great deal more operating experience has been obtained. There is a considerable incentive to increase the limiting rpm, since a 5 per cent speed increase will raise the sea-level rating by 12 per cent.

Another speed-limiting factor at low ambient temperature may be the Mach number of the air relative to the compressor blades. The compressor was somewhat conservatively designed for 25,000 ft, 500 mph, which corresponds to a ram temperature of 14 F. Sea-level tests at 20 F show no evidence of limiting Mach number, but high-altitude tests at low air speeds will result in ram temperatures of 50 F below zero, and the compressor performance in this region has not yet been determined by test.

Combustion Temperature. The maximum combustion temperature of 1900 F is determined primarily by the limiting turbine-bucket temperature, which is also a function of turbine pressure ratio. At sea-level standstill, the limiting temperature is 1880 F for a standard day. As shown in Fig. 13, the shaft power is zero for about 1030 F combustion temperature, and increases nearly linearly with temperature rise at the average rate of 11.8 per cent of maximum rating per 100 deg F. The continuous or normal rating of 85 per cent of the maximum or take-off rating corresponds to a combustion temperature of 1740 F. The sea-level tests have been conducted at rated temperature conditions, and the performance of four different engines fall within the test band shown in Fig. 13.

The increased specific fuel consumption at reduced output, as shown in Fig. 11, is less pronounced at low ambient temperature and high air speed, but there is still a considerable incentive to operate at rather high power, which results in high cruising speeds for airplanes designed around this power plant.

Ram Pressure. Ram pressure is defined as the impact or total pressure of the air stream at the compressor inlet.

If the other four variables under discussion are held constant, the shaft power plus mechanical losses will be directly proporportional to absolute ram pressure. Since the mechanical losses are largely fixed losses, their percentage effect is large at low ram pressures. Under these conditions, the air flow, fuel flow, and jet thrust are also directly proportional to ram pressure.

For a given ambient pressure and temperature, and air speed, the ram pressure obtained will depend upon the inlet-duct loss and on the efficiency with which the velocity energy of the air stream relative to the airplane is converted into total pressure at the duct entrance. Ram efficiency may be defined as the adiabatic-compression work from ambient pressure to ram pressure, divided by the velocity energy of the airplane relative to the atmosphere. The performance curves assume a ram efficiency of 90 per cent.

The combined effect of ram pressure and ram pressure ratio on shaft power and specific fuel consumption is shown in Fig. 14, as a function of ram efficiency.

Ram Temperature. Regardless of ram efficiency, the impact temperature of the air at the compressor inlet must be higher than the ambient temperature by an amount equal to the velocity energy of the airplane relative to the atmosphere, divided by the specific heat of the air.

A change in ram temperature causes a change in air flow, compressor work and pressure ratio, turbine output, shaft output, and jet velocity. The effect of ram temperature on shaft power, specific fuel consumption, and jet thrust is shown in Fig. 15. The reduction in temperature at high altitudes does much to offset the reduction in pressure. For example, at 40,000 ft, 400 mph, and normal rating, shaft output 756 hp, specific fuel consumption = 0.656 lb per shp-hr, and jet power = 139 thrust hp. For the same altitudes and speed but with standard sea-level ambient temperature, shaft output = 347 hp, specific fuel consumption = 0.882 lb per shp-hr, and jet power = 48 thrust hp.

Ram Pressure Ratio. Ram pressure ratio is defined as the ratio of compressor-inlet total pressure to the static pressure at the outlet end of the exhaust cone. With constant ram pressure and temperature, change of ram pressure ratio results only in a change of turbine and exhaust-cone pressure ratio, and therefore changes only the shaft power and the jet velocity, and not the air flow or fuel burned. Fig. 16 shows these changes for normal power operation at sea level.

RESULTS OF OPERATION AND TESTS

Dynamometer tests of the power plant were made in 1943. Only limited full-speed high-temperature operation was obtained within the next year, due to an unexpectedly large amount of turbine-bucket breakage and the unavailability of spare parts. These original buckets were of cast vitallium and had been given extensive x-ray and Zyglo inspection. However, after several failures, it was found that a defect was occurring in 1 or 2 per cent of the buckets just at the junction of the blade and cover. The casting method was changed and forged buckets were employed with great improvement in bucket life. Enough full-speed tests were made to prove that the compressor air flow was almost exactly the designed value of 22 lb per sec, and the efficiency as measured by the temperature-rise method was definitely better than expected. The turbine performance gave evidence of being satisfactory at high pressure ratios, but was disappointingly poor in the starting region. It was redesigned in an effort to improve the starting performance. This objective was attained, but with some sacrifice of high-power performance. A compromise design which should result in improved high-power performance is now under way

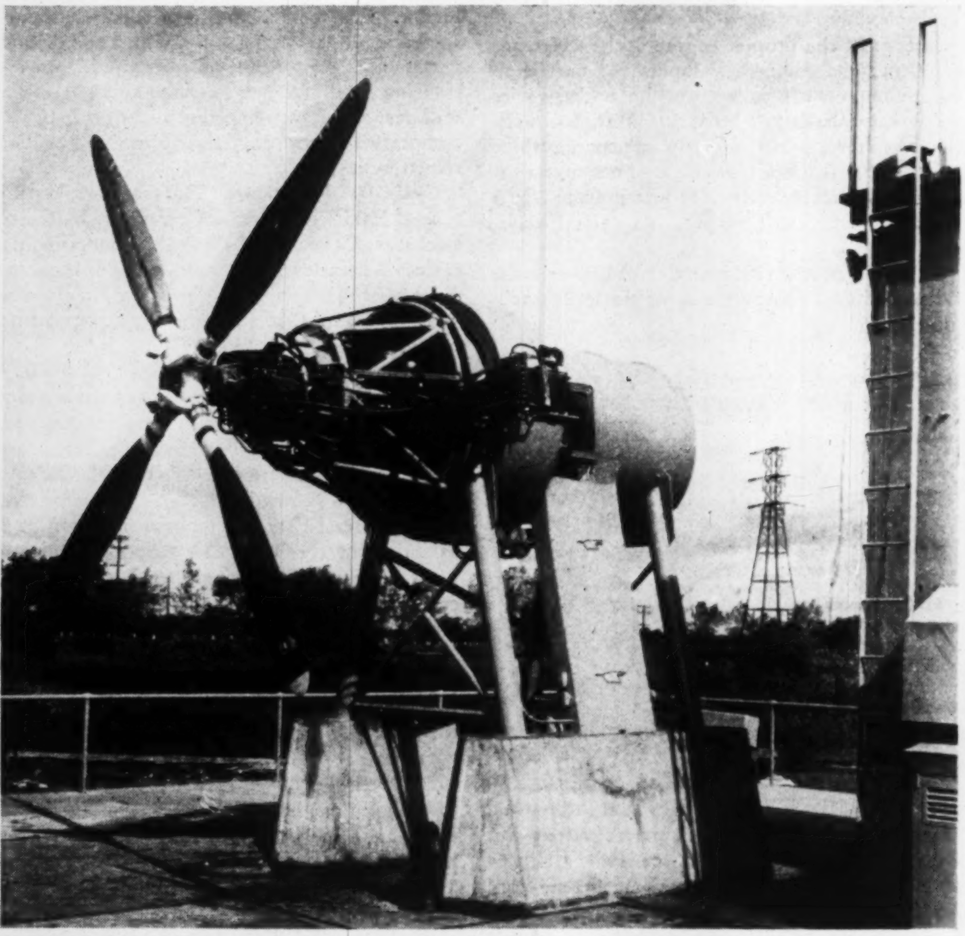


FIG. 17 OUTDOOR ENGINE TEST STAND AT SCHENECTADY
(With engine instrumented for performance tests.)

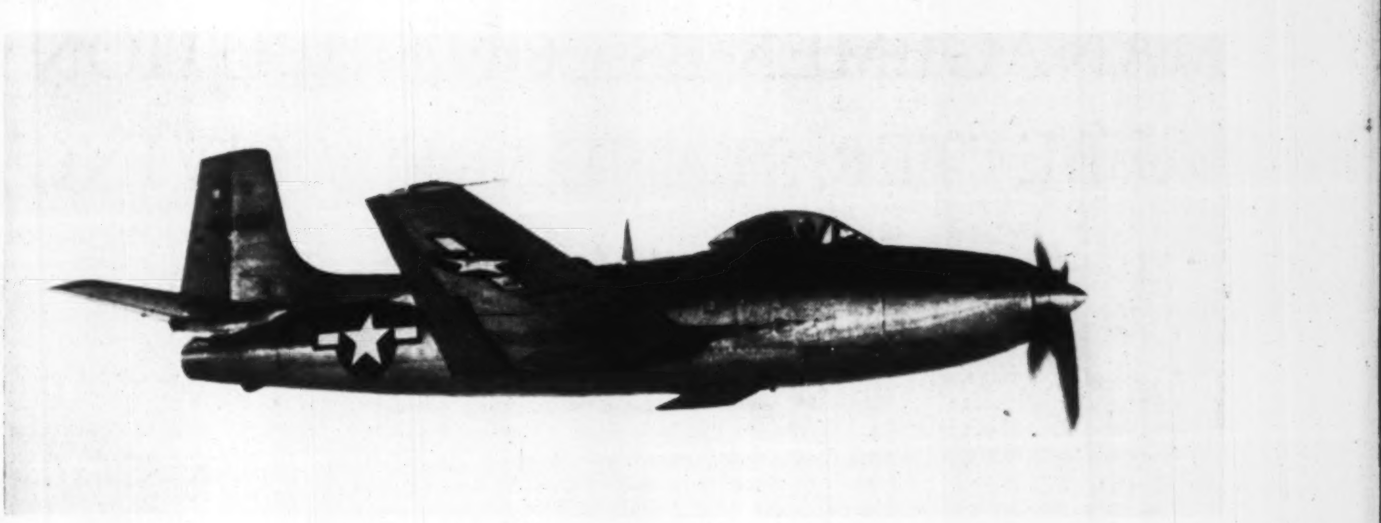


FIG. 18 CONSOLIDATED VULTEE XP-81 SINGLE-SEAT FIGHTER WITH TG-100 PROPJET DRIVING THE PROPELLER AND THE I-40 TURBOJET IN REAR

The reduction gear and accessories were put on the test engine in August, 1944. In the meantime, development of fuel and combustion systems, the control system, turbine-wheel cooling, compressor-rotor construction, the starting-motor clutch, and a gear with relocated accessories was carried on.

The original compressor rotor turned out to be more flexible than it should be, and critical-speed trouble was encountered on several occasions. The rotor has been made stiffer and no trouble has been experienced since.

A complete engine with the present gear and accessory system was run on the dynamometer test stand near the end of 1944. Since then many other complete engines have been produced and tested on dynamometer stands, propeller stands, and in numerous flights. Fig. 17 shows one on test at Schenectady, N. Y.

Up to January 1, 1947, operating time of all engines totaled 1400 hr, of which about 400 hr of operation were with propellers, and the remainder on dynamometer stands. There have also been about 40 flight hr. The original test engine was operated about 700 hr, during which it was overhauled several times and had many parts replaced, some because of failures and some in order to try out new designs. It is now out of service, as a museum piece.

No attempt has yet been made to run a 150-hr-type test, but an 18-hr continuous run has been made, and 56 hr of noncontinuous operation have been obtained without repairs to the engine. Much more operating experience will be necessary before the life of specific parts can be definitely stated, partly because at this stage of development, design and manufacturing improvements are being made continuously. In general, the high-temperature sheet-metal parts have the shortest life. These include combustor liners and transition pieces with a life on test stands of 100 to 200 hr with some straightening and repair welding. Exhaust-cone life is somewhat shorter and is around 50 hr, with evidence that the latest designs will have considerably longer life. Cast turbine buckets last 50 to 150 hr and forged buckets 200 to over 400 hr. It has been found feasible to cut out and replace individual buckets, and also to rebucket completely the turbine wheels. Although in the early stages of the development many turbine buckets were lost at full rpm, not one has yet penetrated the exhaust cone. The life of the other main parts is indefinite, but is believed to be greater than 300 hr.

Definite deterioration in performance during extended runs under factory test conditions has been noted. This is attributed mainly to leakage of lubricating oil into the compressor inlet. The oil bakes on the high-pressure-stage blades, and acts as an adhesive for dirt in the air stream. The application of seal rings to the gear-casing joints and improved piping technique are expected to alleviate this situation, but it is evident that extended operation in a dirty or oily atmosphere will affect adversely the compressor performance. Such conditions should not be encountered in flight. Means of cleaning the compressor without disassembly are being investigated and are promising. These include spraying solvents through the machine during operation.

The engine is started by turning on the ignition and starter and opening the throttle. At about 1800 rpm, the fuel pressure builds up to about 100 psi, and ignition occurs. The throttle is retarded to hold about 70 psi fuel pressure, and the engine accelerates while the tail-pipe thermocouples come up to temperature. The throttle is gradually advanced during acceleration to hold about 1500 F exhaust temperature. The starter is turned off at about 4500 rpm. Improper starting technique may give a burst of flame from the exhaust cone for a few seconds after ignition occurs, but on a normal start no flame emerges from the cone. The starting time is determined mainly by the inertia of the main rotor and the cranking speed required before the engine will run itself. With a propeller, it takes about 120 sec to reach idling speed, 10,000 rpm. With no load, the engine will accelerate from idling to full speed in about 5 sec. Load can be applied as fast as the propeller mechanism can operate to increase the pitch, which may require from 2 to 8 sec from no load to full load.

At full speed and no load, the engine is very quiet compared with a conventional engine. As the propeller pitch is increased, the propeller noise builds up rapidly and at full power, it is making practically all the noise.

At full load, with about 1300 F exhaust temperature, the exhaust cone glows a dull red even in daylight. At the propeller stand, it is possible to look diagonally up the exhaust cone and see the bright-red turbine buckets. The layman seems to expect this of a gas turbine, but the engineer who knows that these bright-red buckets are traveling at nearly twice the velocity of a pistol bullet recognizes this as something a little unusual.

MANAGEMENT'S CONTRIBUTION *to a* BETTER STANDARD *of* LIVING

By WILLIAM L. BATT

PAST-PRESIDENT AND HONORARY MEMBER, A.S.M.E.

On the basis of appraisals provided for him by the National Committees of the participating countries, Dr. Batt reviews trends in the management movement since the Seventh Congress held in 1938. An attempt is made to define "standard of living," which, in spite of differing economic conditions and national aspirations, apparently has the common quality of constant betterment. Turning to the management movement in the United States, Dr. Batt summarizes briefly the substance of the papers contributed by American authors relating to the effect of management in this country on the living standards of people at work, of people as consumers, of people as citizens, and of the individual. In conclusion Dr. Batt states that "in the world of today and tomorrow good management is well-nigh synonymous with even higher standards of living. For good management is guidance, and good guidance brings advance."

THE task of discussing the progress made by management since 1938 and of relating those advances in terms of management's contributions toward a better standard of living everywhere has been assigned to me.

You will be the first to recognize and appreciate my difficulties. The subject is a most appealing one. But its very breadth and sweeping generality are such as to warn a man as old as I am.

I believe all of us can agree, however, that in the problem of raising standards of living everywhere lies our greatest hope of making and consolidating the economic peace that will give substance to political peace. My fervent hope and prayer is that the work we do here can point our course toward the establishment of higher standards of living that will provide more of the good things in life to more people at lower cost than ever before in the history of the planet. By so doing, we can do much to heal the jealousies and envies of the world and measurably diminish the cause and will to wage war.

So we come to the problem of considering practical ways and means of working to raise the standards of living of nations and of men. In attacking this problem there may be little difficulty in arriving at common agreement on the broad principle, but great difficulty in adequately defining the specific areas of the problem so as to indicate acceptable conclusions and realizable objectives.

DEFINITION OF STANDARD OF LIVING

Let us take the problem of defining a measure for a standard of living; of considering what constitutes its components. Perhaps we shall find that there are areas of agreement sufficiently extensive to promise some worth-while answers from meetings like the present. From an analysis of the American papers which are the only ones I have seen, I should come to such a conclusion.

As a first broad qualification, I assume we shall all agree that a constant improvement in man's standard of living is desirable and that better management will make a contribution to that end. Without that major premise we should not have come these long distances to seek means of improving management's contribution to a better world. All of us will, I suppose, accept the basic conclusion that management's function in the use of labor and capital has no justification for existence except as it serves to aid in the better production and distribution of the goods and services deemed necessary or desirable by society.

As a second qualification, I wonder if we can define what constitutes a standard of living in any broad and comparable terms? I have been unable to do so. An American may succeed in setting certain goals for his own countrymen, but they are likely to be on terms relative to what he already has and the directions in which his own national aspirations lie. They may be purely material in nature—more houses, more automobiles, more radios, more refrigerators; they may lie in the cultural area—better education, better facilities for the use of leisure time, and so on.

A Swede may measure his hoped-for economic objectives in wholly different terms and for quite different items. I shall not attempt to spell those out but shall only point to the general conclusion that, in character and volume, the aspirations of any one country may bear little comparable relation to the aspirations of another.

However, these economic objectives will all have one common characteristic, I believe; and, if we can accept that, we are well on the way to a major agreement of some significance. It is the quality of ***constant betterment.***

People of all countries will desire something which will seem to them an improvement over what they now have. As an example of this longing, they are all likely to desire for their children something better than what they themselves have had.

The lower the scale of present living, the smaller and more material one's ambitions are likely to be. The man who has had difficulty in maintaining a thatched roof over his poor cottage will not aspire to aluminum shingles. But he will despair of a society and its management which do not promise him some betterment. Many men will not venture to wish for an automobile or an electric refrigerator, but most men will have a vital interest in earning enough by their labor to buy shoes and shirts or bread, and they will increasingly insist that some decent part of the return from a day's work be available for items of living that are not merely bare essentials.

So while the objectives that constitute this variable standard of living will differ from place to place, ***the tools that management will use*** will not show such differences. The challenge to this Congress, as I see it, is to picture those tools and their use in

---

Address delivered by the President of the International Committee on Scientific Management at the opening session of the Eighth International Management Congress, Stockholm, Sweden, July 3–8, 1947. Slightly abridged, principally by omission of introductory paragraphs which were liberally quoted in an account of the Congress, MECHANICAL ENGINEERING, September, 1947, pp. 788–792.

such form that management everywhere may be able usefully to employ them in raising *all* standards of living.

TREND OF MANAGEMENT IN VARIOUS COUNTRIES

After the decision had been reached to hold this meeting, I made it a first point to ask the National Committees of each country to give me a brief appraisal of what had happened to the management movement in their respective countries since our last meeting. I find everywhere in these reports convincing evidence that good management is at least as well appreciated today as it was at the time of the Seventh Congress.

In the occupied countries, particularly, management activities have apparently been a powerful spiritual force in maintaining courage and confidence.

In Greece, for example, where one might assume that any concerted management activities would have been impossible and where the environment was the most severe, public meetings were not permitted. Their place was taken by circulars and pamphlets, and underground gatherings were held in the interest of rehabilitation. With liberation, such a spirit turned interestingly to a few basic activities, such as special education, organization and research, and the attempt to apply management principles to national reconstruction. Here, obviously, we see management fighting, not for an improved standard of living, but for the bare existence of standards of living.

Where the pressure of the enemy took a different form, perhaps, we find study committees, courses, and lectures being favored, as in The Netherlands.

In Belgium, research and inquiry centered upon materials, products, equipment, labor, and working methods, because of the extreme economic scarcity.

The Czechoslovakian report relates how scientific management, brought under a cloud of criticism as a result of the long depression before the war, fully regained its prestige during those dark days and is now widely looked to for guidance.

The report from France brings out the significant point that during the war the thinking swung away from so-called scientific management, in its narrower technical sense, to that type of management which concerns itself with administrative, economic, and social problems. The whole French report is truly an extraordinary statement.

In many of the occupied countries, an inverted development took place. Good management turned on itself and became skilled in the art of sabotage in production—a curious and, under the circumstances, proper inversion of the art and science.

In England, the prolonged bombing and the difficulties under which the British lived and worked during the war unquestionably placed obstacles before the management movement. Here we see the necessity for maximum production amidst the difficulties of survival developing an extraordinary growth of interest in associations, institutions, and the like for the purpose of disseminating management principles. British management is quite obviously anxious to speed the improvement of new ideas for the proving ground to widest national application in the least possible time, and so to make maximum impact on the standards of living of that country.

The recent formation of the new central body of the British Institute of Management, with substantial funds at its disposal, will provide a mechanism through which these aspirations of British management may be given a noteworthy opportunity for development.

The reports from neutral countries have been so brief as to give little basis for comment. One readily understands the hazardous position in which these countries found themselves for so long, the sharp limitation of many of their critical materials, and the constant state of tension in which their management was carried on.

As to the United States, I hope not to be misunderstood if I speak at some length. Citizens of the world recognize that the sudden development of natural resources and the cumulative impetus of a century and a half of free enterprise have brought her to a top position in world affairs.

At a time when there is still so much misery and actual hunger in so many parts of the world, I would not for a moment wish anyone to consider that my remarks about the United States are made boastfully. I am not unmindful of the fact that this was one of the few countries at war whose physical plant was undamaged but, rather, was larger at the end of the war than before. Civilians experienced few of the physical hazards of war and management was relatively free to perfect its methods.

In the light of these resources, I think I am justified in pointing to a growing determination on the part of the responsible leaders in all walks of American life—and they reflect the desires of the people— that the economic resources of the United States shall be used to implement the deep-seated wish of the American nation for lasting peace based on an increasingly better standard of living for the individual citizen of the world.

One may fairly point to the record of production of the American people during and since the war as an evidence of what can be done by a democratic people with good management.

In the light of the universal concern over America's economic stability, I should particularly emphasize the growing consciousness in America of the problem of maintaining employment. In the meeting at Washington, you will remember the emphasis which many American authors placed on the responsibility of management to the various segments of the economy, to the customer, to the employee, to the public, and last but not least, to the stockholder. This concept has continued to meet with wider and wider acceptance, and there are few American corporations today which are not studying the problem of finding ways and means of welding the components of the economy together to achieve better understanding and closer community of interest. The successful application of this philosophy is not without consequence to the rest of the world, for the reason that the important part played in world trade by the United States will inevitably have far-reaching repercussions on international prosperity.

EFFECT OF MANAGEMENT UPON THE LIVING STANDARDS OF PEOPLE AT WORK

The papers presented by the representatives of the group from the United States deal effectively with the relation of management and living standards. If I seem to base my comments so largely on the American papers, you will understand that it is because they are the only ones to which I have had access; I assume that the papers from other countries make similar contribution to a better understanding of this objective.

Production and Social Standards. There is a noticeable emphasis upon raising the living standards of people at work. For example, better building design conserves the nonworking time of employees; improved plant layout increases human convenience; better materials-handling techniques lessen physical effort; more precise planning and control eliminate unproductive idleness and loss of continuity. Work simplification, which has been widespread, is in reality no more than fitting the process and the equipment to the man, rather than has reverse.

Working Conditions. Improvement of working conditions the had much attention. It is obvious that the objective of betteer ing the surroundings at the workplace is regarded as increasingly important. The wartime need for the greatest possible volume of output, coupled with the shortage of labor, unquestionably made such policies worth while from the standpoint of production. One gain to come out of the war has been the widespread realization that people live the most important part of their waking existence at their work, and when they look back at their work, they are, in general, looking back at their lives. This improved environment incorporates mental health and safety no less than physical security. Much more remains to be done to improve conditions in such fields as equity of wage relationships, closer adjustment of human abilities to job requirements, and the like.

Lessening of Physical Effort. The advance made in mechanized materials handling deserves a subdivision of its own. Particularly in the agricultural industry, increasing power-machine usage has unquestionably raised productive standards of living tremendously. I think it can safely be said that heavy physical effort is now irrevocably obsolete in American industry. This advance is perhaps one of the greatest outgrowths of the war; for its natural development was hastened because of wartime exigencies, particularly through the increased use of female labor which required that power take the place of muscle. Prior to the war there was a steady growth in the availability of power per worker in the United States. During the war years, for reasons not quite clear to me, that growth lagged; but under conditions of peace it re-emerges as a desirable objective, and there is every indication that the years to come will show a constant increase in this power availability per worker. The results, in terms of living standards at the workplace, will be obvious.

Training. Good management in the education and training areas has unquestionably been responsible for marked contributions to the worker's standard of living. Not only has his potential capacity thus been released so that he has been able to train himself for positions of larger compensation but, more frequently, his continued adjustment to the rapid changes brought about by research and development has been made possible. The noticeable reduction in the hazards of unemployment as a result of technological improvement is to a considerable extent a matter of facility in readjusting skills and capacities to the ever-changing requirements of process and operation. In the United States the period of the war showed extraordinary progress in this field.

Personnel Activities. The current great growth in the field of personnel management has a salutary effect upon working and living standards, inasmuch as its concern is with the "total working situation." I can foresee no dissent from the conclusion that personnel administration, in its broadest sense, is essentially devoted to the rise of living standards of the industrial worker.

Agriculture and the Home. The foregoing statements apply with equal emphasis to production on the farm and in the home. Much of our living takes place in or around the home and the farm, and it follows that any contribution of management in these areas will directly enhance the standard of living. Here the objective toward the living of free, rich, and satisfying lives will manifest itself most obviously as a possibility of better management. In the United States, there is the challenge today to assist in maintaining a standard of living in the middle-class families where domestic paid help has always been a problem, but is a particularly acute one now when postwar conditions have almost eliminated reliable domestic help from the market.

Great strides have been made in improving the standards of work in the office. Here we may discover the interesting fact that, not infrequently, working conditions, conventions, and customs are definitely in advance of those at home. Living standards of many people are thus more affected by office than by domestic standards.

EFFECT OF MANAGEMENT UPON THE LIVING STANDARDS OF PEOPLE AS CONSUMERS

Again and again, various papers make the statement that it is, after all, the products in the markets available to the consumer which have the greatest effect upon living standards. While industrial goods will be those first thought of, the largest share of the individual income goes for items having to do with food, shelter, and clothing. These are the bases of normal existence, and it is important to note that they are also essentially industrial goods. Good management in production and in distribution of consumer goods has the effect of increasing quality, improving service, and enlarging the opportunity of use. It strikes clearly in the direction of enhanced living standards. The platform, so widely emphasized in the Seventh Congress (1938) of more goods for more people at lower prices is accepted by the authors of the papers for this Congress with even greater unanimity.

Purchasing Power. While we are apt to think of producer income as related only to production, it is in reality an aspect of consumption in so far as living standards are concerned. The larger the purchasing power of the public, the higher its living standards; the better the management, the higher the individual return as a result of economic and efficient operation. It is now generally accepted, I think, that human wants are well-nigh insatiable and, speaking broadly, depend only upon purchasing power for their satisfaction There apparently is no doubt in the minds of the American authors that the United States, at least, has the production capacity to make all that it needs and in ample surplus. Better world-wide management will increasingly find the means of making that surplus available to other parts of the world whose mechanization is less adequate.

Distribution. Good management in the field of distribution will create a powerful and direct thrust toward higher standards of living. Granting the premise in the earlier paragraphs that human wants are insatiable, they must necessarily be guided and directed toward those areas where satisfaction is both practicable and possible. Here, the marketing functions having to do with publicity and sales promotion exert a direct and vital influence upon living standards. Good management is of the essence of progress, for it tends to stimulate consumer wants which can be practically and commercially satisfied in terms of purchasing power.

Research and Development. In the papers which deal with research and development, the significance of management in its bearing upon the consumer is shown. Through organized innovation, new and improved ratios of value to process can be conceived, and it is these which will make for the heightened industrial flow which lies at the base of national prosperity.

The new managerial developments in *planned research* will unquestionably have more bearing on the acceleration of *extensive* improvement, and its correspondingly enlarged employment, than any other immediate influence. It will be this development which will tend to compensate for the hazard of that unemployment which comes with *intensive* improvement. The use of this comparatively new management tool—product planning and development—is still in its elementary stages, but it offers definite promise as a constructive and powerful influence in the enhancement of living standards.

Quality Control. One of the most interesting facts to come to light has been the effect of management in quality control upon standards of living The development of statistical con trol and what the authors term "quality plateaus" is contributing to the ability to achieve high commercial quality at costs materially less than those characteristic of lower-quality lines manufactured under earlier and poorer practices. Progressive management in quality control is demonstrating that high product quality can be obtained at relatively low unit cost where the quantity is sufficient to justify high-precision mass-production techniques. As these principles can be utilized, they should have a direct and revolutionary impact upon consumer living standards of the future.

Cost Accounting. Progress in cost accounting drives squarely and constructively into areas of living standards, inasmuch as it is chiefly through cost control that effective cost-price relationships and resulting industrial flow can be preplanned and assured. The heightening of this flow means the raising of living standards.

Postwar requirements call for individual analyses in individual establishments of cost factors whose balanced interrelationships contribute to high manufacturing turnover. This the cost division alone can do. It is significant to note that the cost-accounting function has been increasingly recognized as an effective tool of management, and this function has acquired a new relation to broad company objectives, policies, and procedures.

EFFECT OF MANAGEMENT UPON THE LIVING STANDARDS OF PEOPLE AS CITIZENS

Through many of the papers presented at the Congress runs the thread of conclusion that improvement in the quality of government administration is intimately associated with the standards of living of the people.

Municipal Administration. In the home area, particularly, there are many things which ***municipal government*** alone can do. The insurance of public health and sanitation standards, the protection from fire hazards, and the maintenance of law and order are but a few of the many areas in which science in municipal management may directly influence a community's living standards. Conversely, economies in municipal operations may either serve to release funds to further these activities or to lessen the burden of taxation upon the individual. In either event, living standards are immediately affected.

Regional Planning. The discussion on ***regional planning*** which centers upon the Tennessee Valley Authority, is a challenging one. Without expressing any opinion as to the desirability of the production of power through public or private sources, I shall assume that TVA may properly be cited as an example of how planning and freedom can be compatible and creative within the framework of democratic tradition. An area of acute distress, crossing many boundaries where the standard of living was undeniably low by any measure and steadily worsening, underwent an extraordinary change for the better.

It would be a mistake to interpret the meaning of this undertaking merely in terms of cheap power. That has been rather a by-product even though an essential one. Even the critics of the project, who will assume that it could have been carried out by some other means, will agree that standards of living for most of the people in the seven states of the area have been given new direction and purpose, that the inhabitants have greatly improved health, that employment opportunities are strengthened, that recreation facilities exist where there were none before, and that the whole region has been reborn with this experiment in management for the public good.

National Planning. In the fields of ***national and international administration***, the same general conclusions obtain as in the municipality. In most countries, national taxation is a measurable burden on the income of the individual and so vitally influences his standard of living. The gains resulting from advanced techniques in public administration lie mainly in the achievement of operating efficiency without loss of democratic guarantees, even in times of national emergency.

International Relations. In the management of ***international relations***, it almost goes without saying that living standards are immediately related to advances in the quality of international administration. As the possibility of conflict between countries is definitely lessened and the atmosphere for world-wide peace and prosperity is improved, there is a lightening of the tax load of the citizen which will add to his spendable income and so relate itself vitally to living standards. As improvements in communication and transportation inevitably continue to develop more intimate international dealings, a corresponding improvement in the management and administration of these activities is vital.

The more acute the need for bettering the living standards in any country or group of countries, obviously the greater the premium for good management. In the war-torn countries, for example, the need for early and substantial lifting of the existence of the individual above the barest minimum is so desperately impelling as to speak for itself; men whose food, clothing, and housing resources are but barely removed from the starvation and freezing limits of existence, will be grateful beyond words to those skills of management which promise to lift their crushing load at the earliest possible moment. The opportunities for management to demonstrate its value in a relatively rich and unhurt economy, such as that of the United States, may be open to more precise definition; but from the tragically burdened people of war-torn regions there will be little likelihood of challenge.

EFFECT OF MANAGEMENT UPON THE STANDARDS OF LIVING OF THE INDIVIDUAL

Much of the preceding discussion has concerned itself with man's living standards as influenced by the conditions which exist at his workplace on the grounds that this environment constitutes the larger portion of his waking hours. There are other considerations of large importance to the better living of the individual, and these I now propose to discuss.

Leisure. The first has to do with the contribution to the larger life which good management will unquestionably make by increasing the amount of ***leisure*** time available. A generation or two ago, the usual hours of factory work were 60 per week and a man had little free time remaining, Weekly working hours are steadily declining and the worker in industry now finds himself with a substantial sector of his time available for recreational and avocational pursuits.

In farm management, the use of scientific principles coupled with the increasing availability of power machinery, have likewise greatly shortened the farmer's working day. Whatever the use of his free time, its availability constitutes a major contribution to the possibility of an improved standard of living.

Education. One of the outstanding characteristics of the last decade has been the extraordinary acceleration of educational activity throughout industry. As never before, employees no less than executives, have been urged to form the habit of acquainting themselves with the changing conditions, procedures, and opportunities about them; and this is but the beginning of a movement which will inevitably provide a new managerial class who will bring a renaissance of creativeness and inquiry throughout the working group.

An unusual characteristic of this tendency is its all-embracing quality. It seems to be worth emphasizing that the possibility of better education for youth in those countries where one of the results of better management has been to provide larger worker incomes, is a compelling satisfaction to the parent.

For the individual himself to have an enhanced opportunity for self-expression as the result of his own individual thought is to make a direct contribution to better living, for man is at best a thoughtful creature, and to give outlet to his mental potentialities is to add to the dimensions of his existence.

Security. The development of man as an individual is closely related to the degree of security which life offers to him. It is only when security is present that long-term advances in personal status can be reasonably assured. Good management, as it continually contributes to economic stability through effecting favorable relationships between the prices of its products and the purchasing power of its markets, is thereby building up its own security and that of its employees. Other aspects of good management which incorporate general policies favoring stabilization of output and thereby of employment serve directly to promote higher standards of living of the individual. It is here, perhaps, that industry makes its greatest contribution to the enhancement of the existence of the worker's family and dependents no less than of the worker himself.

CONCLUSION

The responsibilities of management are today viewed against the wider background of their social and human contributions instead of merely measured, as in the past, by their purely technical and scientific achievements.

Planning is, after all, man's way of controlling his environment. As someone has said, "We control the present only as we plan the future." Good management uses foresight in order that the future may be assessed and directed before it becomes reality. The standards of living under such intelligent planning are likely to be far more favorable than those where the future has not been studiously assessed.

The setting of goals, which lies at the heart of scientific management, is nothing more than the definition of an attainable ideal. The human creature has always risen to the challenge of a set standard, whether its goal be the "quota" as in production, the "budget" as in accounting, or "par" as in golf. More than this, the elasticity of human effort is so large that, once the goal is fairly set, its attainment results from will no less than from work.

As long as there have been animate creatures on earth, there has doubtless been some form of organization; and good management as it employs the principles of good organization only renders environment more satisfying to the human creature. With millions of years of gregarious existence behind him, man tends naturally to co-operate and live with others. It is only when poor organization or faulty custom or convention interfere with natural tendency that ineffective action results. Once again, good management aims but to release a human tendency.

As before stated, much if not all of the study of methods is directed toward a more favorable adjustment of work demand. The early advent of machinery reversed this trend for a century or more, but now the once ebbing tide is in full flow and on every hand there is evidence that the work of the world is rendering machinery subservient to the convenience of the individual rather than the contrary.

Finally, human effort may be said generally to be the component of four influences: namely, the hope of reward; the fear of penalty; the assurance of promise; and the inspiration of an ideal. Good management serves to implement all of these to the end that man fulfills his function as a creature of action—a dynamic entity.

In the world of today and tomorrow, good management is well-nigh synonymous with ever-higher standards of living. For good management is guidance, and good guidance brings advance.

Product Planning[1]

THE planning and development of suitable products to which manufacturers' production and distribution facilities can be most effectively devoted is a critical problem area to which management in the United States is giving increasing attention. Among new products are included competitive variations of existing products as well as those that are fundamentally new.

Though the problem of the continual adjustment of products (or services) to individual company capacities and to market opportunities is basic to all types of enterprise, this paper[1] is directed especially to the problems of manufacturers, omitting those of distributors or of service enterprises. Also excluded from special attention are the problems unique to manufacturers of products in which rapidly changing fashion is a dominant characteristic, or to firms doing only custom production or making specially engineered items for individuals.

The scope of product planning activity includes:

1 Planning relating to fields for company product activity. This involves consideration of a company's objectives and necessities and of its areas of strength and weakness
2 Initiation of specific product ideas and the preliminary evaluation of them
3 Development of a specific product or group of products including any necessary technical research
4 Evaluation of the market demand in general product fields and of the acceptability of specific product forms.
5 Reduction to practice of specific products, including their introduction into manufacturing and into the market.

Among the many important business management activities, product planning and development has, in the past, received surprisingly little public attention. The over-all problems and methods of handling this function efficiently have not had the benefit of searching and objective analysis, commensurate with their importance. This omission has been due in part to the specific nature of product problems in individual enterprises, and in part to a failure fully to recognize the need for correlating product thinking with other areas of managerial study. Too often products have been assumed to be entirely satisfactory, or their planning and control has been relegated as a secondary activity to some single department, usually production, engineering, or sales. With renewed competitive pressures and projected higher levels of business activity, industry cannot afford to continue these practices which current conditions have rendered obsolete.

The war sharpened interest in new products and in more adequate product planning. Wartime brought a discontinuity in production and sales routines. Many companies expanded personnel and facilities beyond the needs of their regular products, and gained experience in what had been, to them, unfamiliar fields. These factors, coupled with a general faith in the postwar future, have served to heighten interest and extend the horizons of product development for individual companies. Wartime experience also brought into clearer focus the possibilities of greatly accelerated rates of technological development when cost considerations were minor. The reduction of such changes to competitive industrial practice has been slow with the return of peace; but the knowledge of such possibilities remains as a constant stimulus.

Management's contemplation of new fields of activities has brought with it a recognition of the need for a more scientific approach to product planning and development.

---

[1] "Management Practice in New Product Planning and Development in the United States," by E. A. Boyan, R. M. Cunningham, and G. B. Tallman, a paper presented before the Eighth International Management Congress, Stockholm, Sweden, July 3 to 8, 1947.

CENTENARY *of the* BRITISH INSTITUTION *of* MECHANICAL ENGINEERS

By R. H. PARSONS

THE Institution of Mechanical Engineers, which celebrated its centenary in mid-June, can look back upon a hundred years of invaluable service both to the profession and to the community. Its existence has been contemporaneous with almost incredible developments in engineering, metallurgy, and general science brought about largely by the work of its members. When it came into being, engineers had no such materials as even mild steel or aluminum, no mineral oil, no artificial abrasives, no electric generators, and no internal-combustion engines of any kind. Their machine tools were comparatively few and simple, screw threads had not yet been standardized, precision measurements were impossible, and scientific knowledge applicable to engineering problems scarcely existed. The steam engine, much as it had been left by Watt, was, however, available for industrial purposes, locomotives were running on the railways, and steam had been applied to marine propulsion.

The Institution was founded in Birmingham on Jan. 27, 1847, by a meeting of some of the leading mechanical engineers of the day, and George Stephenson, who had taken an active part in the proceedings, was elected by acclamation as its first president. The object of the Institution, in the words of its founders, was "to enable Engineers . . . to meet and correspond, and by a mutual interchange of ideas . . . to increase their knowledge and give an impulse to inventions likely to be useful to the community at large." Birmingham was decided on as its headquarters, as being the most convenient center for engineers engaged either directly or indirectly with the development of railways which then constituted one of the most important fields for engineering activity.

After the death of George Stephenson on Aug. 12, 1848, his son Robert, who acquired the same unrivaled eminence as a railway engineer, was elected president of the young Institution. Other well-known names, such as Fairbairn, Whitworth, Penn, Armstrong, Napier, and Siemens[1] among the early presidents, bear witness to the prestige the Institution has enjoyed since its inception. In 1856 it took a step which greatly extended its influence and usefulness. This was the inauguration of its annual summer meetings, lasting two days or more, and held in some selected industrial center or sometimes abroad. Such meetings have remained among the most appreciated functions of the Institution. An outstanding event in the history of the Institution took place in 1877, when the headquarters were transferred from Birmingham to London. At this time the membership was somewhat more than a thousand. In 1895 it began the construction of its present worthy home at Storey's Gate, St. James's Park. This was formally opened in 1899, and considerably extended in 1913. By then the Institution comprised more than six thousand members, and the rapidity of its subsequent growth is shown by the fact that at the end of last year it had almost 25,000 members of all classes, to which must now be added the considerable number of members recently admitted by the absorption of the Institution of Automobile Engineers.

The increase of membership from all parts of Britain led, in 1920, to a measure of decentralization, whereby local branches, managed by their own committees, which are represented by their chairmen on the Council of the Institution, were established in large centers of population. There are now nine such branches, covering between them the whole of Great Britain each providing opportunities for its own discussions and other activities. Similar branches also exist in China, the West Indies, and the Argentine, while advisory committees serve the interests of the Institution in seven other countries overseas. Another outcome of the increased membership has been the formation of specialized groups within the Institution. These are composed of engineers having a common expert interest in particular subjects, as, for example, steam, hydraulics, internal-combustion engines, manufacturing, education, and so on. These groups are assisted by the Council in arranging their own meetings and discussions.

Thanks mainly to benefactions by its members, the Council of the Institution now has at its disposal valuable funds for the provision of monetary awards or medals for special lectures or particularly meritorious papers. One of its highest awards is the Watt International Gold Medal, which is bestowed biennially on some distinguished engineer, without regard to nationality, for exceptional services to science or industry. The decision is made by the Council in the light of the opinions of the leading foreign institutions, and the recipients so far have included two Englishmen, two Americans, one Australian and one Swiss.[2] Some of the other prizes are awarded in respect of specified subjects, but in the case of others the Council has a wide discretion. Any person, for example, whether a member of the Institution or not, may be invited to deliver the well-known annual Thomas Hawksley Lecture. Lectures in this series have been delivered by such authorities as the late Sir

---

[1] Sir William Siemens was elected an honorary member of A.S.M.E. in 1882. Other I.M.E. past-presidents who have been or are honorary members of the A.S.M.E.: Sir John A. F. Aspinall (1911), Edmund Bruce Ball (1939), Sir Frederick Joseph Bramwell (1884), William Cawthorne Unwin (1898), Sir William Henry White (1900), Harry R. Ricardo (1942), and Sir William Arthur Stanier (1945). A certificate of honorary membership in A.S.M.E. was presented to Lord Dudley Gordon, president I.M.E., 1947, during the Centenary Celebration.—Editor.

This article appeared in *Nature*, June 14, 1947, and was made available for reprinting by British Information Services, New York, N. Y. Mr. Parsons is author of the Centenary Memorial Volume, "A History of The Institution of Mechanical Engineers, 1847–1947," published by the Institution.—Editor.

[2] Of the Watt medalists, Sir John A. F. Aspinall (1937) and Dr. Aurel Stodola (1941) were honorary members of A.S.M.E.; Henry Ford (1939) was a member and Holley Medalist (1936) of A.S.M.E.; and Dr. S. Timoshenko (1947) is a fellow and Worcester Reed Warner Medalist (1935) of A.S.M.E.—Editor.

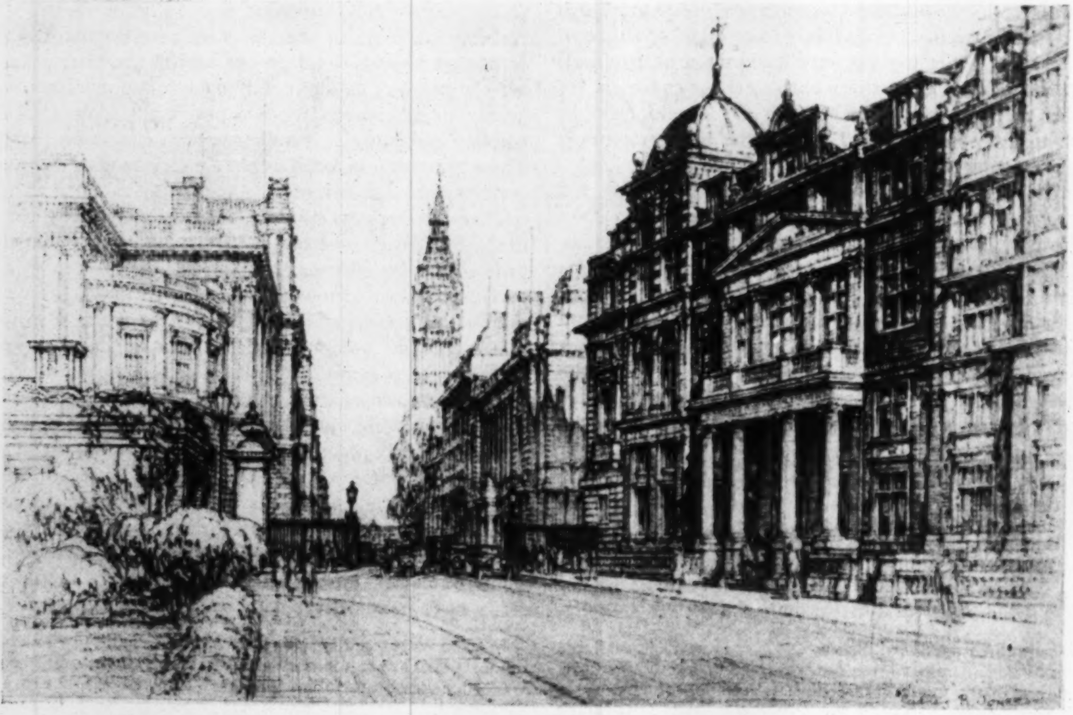
Alfred Eddington, the late Lord Rutherford, and others of similar eminence. In 1945 the Institution received the magnificent bequest of £130,000 ($520,000) under the will of the late Mr. James Clayton with the condition that at least one quarter of the annual income should be used in providing a "James Clayton Prize" for the best contribution by any member in that year to modern engineering science. The first award under this bequest was made to Air-Commodore Frank Whittle for his development of jet-propelled airplanes.

It may fairly be claimed that no other technical organization has so fine a record as The Institution of Mechanical Engineers in the matter of corporate research work, carried out for the benefit of the profession in general. So long ago as 1875, the Council adopted a policy of giving financial support to engineering research, and in 1879 it appointed a standing research committee to decide on and supervise such investigations as might be desirable from time to time. Very large sums have been spent by the Institution on such work, which has been carried on uninterruptedly ever since. The results of the various investigations form the basis of discussions by the members, and are then published for the benefit of all persons interested. The range of subjects is too great even for a summary here, but mention ought at least to be made of the classical experiments of Beauchamp Tower in 1882, on which the whole of the modern theory of lubrication is based, and of the work of the Alloys Research Committee which was started under the direction of Sir William Roberts-Austen in 1889 and has since been productive of immense advances in metallurgical knowledge. The Institution also took up the question of standardization at an early date, and played an active part in the establishment of the Engineering Standards Committee in 1901, to which body matters concerned with standardization have since been referred.

The Institution Library now comprises more than 35,000 volumes, arranged accessibly for consultation, and also available for loan to members who wish to borrow them. There are, in addition, some two hundred British and foreign current technical periodicals in the Reading Room. Visits to the Library or Reading Room now exceed 10,000 annually. The assistance and advice of the staff are, moreover, at the disposal of members seeking information either personally or by correspondence, and the necessary searches are carried out for them.

To maintain the high standard of qualifications required for admission to the Institution, after 1912 the election of the younger candidates was made conditional on their passing an examination in general and technical knowledge in addition to the conditions previously demanded, except in cases where the possession of an approved degree or diploma rendered any further examination unnecessary. The interest and the influence of the Institution in engineering education led to its being consulted by the Board of Trade in 1921 when the advisability of revising the old "Science and Art" examinations was under consideration. The outcome of these discussions, largely due to the late Dr. H. S. Hele-Shaw, was the establishment of the present system of National Certificates in Mechanical Engineering. These are granted on the result of examinations in which assessors appointed by the Institution can set up to 40 per cent of the questions, and can render compulsory and particular questions up to the same percentage of the total. The Institution thus exercises a very strong influence on the type of education given. The certificates awarded bear the signatures of the president of the Institution, of an official of Britain's Board of Trade, and of the principal of the educational establishment concerned. The number of students who sat for these examinations in 1946 was nearly 12,000. The Institution shows its confidence in the scheme by exempting the holder of a Higher National Certificate from further examination in the subjects covered.

In 1929 The Institution of Mechanical Engineers was granted a Royal Charter in recognition of its position as the accepted embodiment of the profession. As such it enjoys the patronage of King George VI, and, apart from the services of its individual members, it has, in its corporate capacity, rendered invaluable assistance to the British Government during and since the war.



HEADQUARTERS OF THE BRITISH INSTITUTION OF MECHANICAL ENGINEERS, LONDON, ENGLAND

THE GROWTH OF INDUSTRIAL STATISTICS[1]

By LOUIS C. YOUNG

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LIKE pioneering in a new world, the development of statistical quality control has created some concentrated isolated growths in a comparatively vast territory. Although all of the different types of statistical application derive from the same race of mathematical probability, they have separately taken root in those industrial fields which have proved most fertile and in which success was most easily to be obtained. The successful application of each type of method has helped, moreover, to establish some succeeding method by clearing a path before it.

There are many reasons why these growths of method—control charts, sampling plans, designs for experiment—should be typical within themselves and seemingly separated from each other by wide areas of still unexploited industrial application. Many of the methods migrated to industry from the somewhat related fields of biology, agronomy, and economics. Many more such migrations are to be expected before industrial statistics will be self-sustaining, that is, yielding solutions to nonindustrial problems in the proportion to which it borrows. There is a trend already in this direction. When that time arrives, industrial statistics will have become so much more generalized as a branch of engineering that many of the present gaps between statistical applications will have been filled in.

In treatises on industrial statistics, the foregoing has been observable in the tendency to present types of problems and their methods of solution, to stress the problems currently being solved by statistical methods, and to place secondary emphasis on the general mathematics which made the solutions possible. This approach has been necessitated somewhat by the difficulty of presenting the entire background of statistical methods in one volume, to say nothing of incorporating examples of industrial application. It has also been desirable because of the heterogeneous mixture of likely readers. Both engineering students and factory personnel have had to be patronized—the former group as familiar with mathematical derivation as the latter group was familiar with industrial problems solvable by means of statistics.

With the stated purpose of providing a book[2] "to serve as a reference manual for practical men, and also as a textbook for college students," Professor Peach has taken a more extreme path than his predecessors. Covering the majority of common industrial problems of quality control and experimental research now being solved widely by means of statistical methods, he has omitted virtually all mathematical proofs. Of the laws of probability he has submitted only that framework which is helpful to an appreciation and understanding of the results to be expected from sampling experiments.

Education in any precise science or field of engineering may be arbitrarily resolved into two parts: the teaching of qualitative aspects and nature of things, and the teaching of quantitative degree. Professor Peach has by no means disregarded the first of these. His explanation of the reasons for each qualitative action of quality-control work (the manner in which samples are to be taken, the reason why sequential sampling may be more economical than single sampling, and many similar cases) are sufficiently explained to convince all but the most skeptical of shop personnel. It is the quantitative side of statistics which he slights in his explanation—giving tables of factors without derivations, and using the factors to determine control and acceptance limits. By thus sidestepping the complicated mathematics which so often confuses and discourages beginners in quality-control work, the author both maintains interest and opens the door to distrust of his final precise conclusion. Inasmuch as many quality-control problems admit only two alternative solutions—action or inaction—it may be that skepticism is thereby relegated to a separate part of the procedure. Although a liberal bibliographical appendix is included for the benefit of those readers who wish to pursue the subject further, reliance upon other viewpoints and terminology is as likely to impair the force of an argument as to strengthen it.

In aiming at his twofold objective of practical reference manual and college textbook, Professor Peach leans somewhat toward the practical side and draws well upon his extensive experience in industry. Whether he had in mind the fact that college students may be given supplementary theory and mathematics in class is not explicitly stated but may be taken for granted. In any case the added weight of practical views and comments may be confidently expected to increase the interest of all groups.

In subject material the author starts his text by establishing the general concept of probability, using dice games and coin tossing in several illustrations. In this as in subsequent chapters the author wastes no words on irrelevancies with which such experiments and their descriptions are likely to abound. Since he uses these experiments as references for several industrial examples in later chapters, he develops fully those sides of the experiments and their results which are pertinent to applied statistics. If he understates anything at this somewhat fundamental phase, it is the viewpoint that dice and coins are more definite in their marking than are most measures of quality, and consequently less subject to the variations of judgment.

Along with the basic definition of probability in the first chapter, the author discusses other things necessary to an understanding of statistics, both general and industrial—the nature of errors, frequency distributions, and common statistical terminology (italicized for emphasis and easy reference). In this way he establishes an explanatory foundation pertinent to all of the methods presented thereafter. The first of these, acceptance sampling, entails further discussion of errors from the viewpoint of enforceable quality standards. Several illustrations of sampling plans show the approximate relationship between acceptance number, sample size, consumer's risk, producer's risk, acceptable quality level, and objectionable fraction defective. These, of course, are the usual factors characterizing a simple sampling plan wherein the material in a lot is judged on the evidence of a single sample from the lot. The average reader will appreciate the fact that the author reduced the number of these factors by employing certain assumptions and approximations. The formulas and procedure presented for determining sample size and acceptance number are clear and easily employed.

---

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "An Introduction to Industrial Statistics and Quality Control," by Paul Peach, Institute of Statistics, University of North Carolina. Published by Edwards and Broughton Co., Raleigh, N. C., 1947, 235 pages.

Using an illustration in which several samples of the same size are taken from a large lot, Professor Peach gradually takes up the principles of a control chart for defectives and shows its similarity to the standard acceptance sampling plan. This thought is developed and expounded more fully in the following chapter. Here he reverts to the dice game in order to demonstrate the meaning and purpose of control limits, in a way which no one could fail to understand and which justifies the following quotation from his text:

> Wherever he [the crap player] draws the line, it will be a *control limit*. In selecting the place to draw it, he might argue somewhat as follows:
>
> "I want to find a balance between two conflicting desires. On the one hand, I do not want to mutilate a good, substantial citizen. On the other hand, I don't want to be given the business by a slicker. Apart from ethical considerations, any recourse to violence is likely to have unpleasant consequences; my conscience thus demands that I give precedence to the objective of sparing the innocent, and secondarily seek for means to cope with the guilty.
>
> "Anybody can make 5 or 6 straight passes, though the odds against making 6 are 63 to 1. The odds against making 9 straight passes are over 500 to 1. If I make it a rule to start using my razor at the 9th pass, the honest man will seldom get hurt and I shall still have some protection against dishonest persons."

In a brief chapter 4, the author discusses variate measurements, and such characteristics as standard deviation, range, and normal distribution, as explanatory preparation for chapter 5 on control charts for variables. Here he draws an expected parallel with the previous control charts for attributes, but is able to give greater detail because of the many practical inferences to be drawn from given examples of average charts and range charts. Both practical men and students will find interest in the author's experience with specific arrangements of averages and ranges of samples and the conclusions reached. In addition to his statistical and practical views on control-chart work, Professor Peach has interjected some comments of a motion-study nature, calculated to make control charts give the same efficacy with less work.

In the following chapter he reverts once more to acceptance sampling and considers such further plans as: Double sampling; sequential sampling; the relation between these and single sampling; the inspection of samples from small lots; average outgoing quality limit inspection; and some other variants of acceptance inspection. Each of these is sufficiently explained to demonstrate the circumstances in which it has greatest utility, and formulas and tables are provided with which to establish the majority of these plans. Sampling of variables is considered in the following chapter, under the general heading of tests of significance, after some introductory pages upon estimates of variance and Students' "t" distribution. The exemplary applications are well chosen and cover a variety of cases.

In chapter 8 on special quality-control methods, and chapter 9 on industrial and scientific measurements, the author interrelates control methods and tolerances with less precision than he used in his preceding chapters. Although the first of these two chapters deals with short-run production and various forms of modified "control" limits, it is somewhat arbitrary in definition and gives little of the quantitative economic aspects which so influence this field. The tolerance relationship in the second of these chapters is subjected to a restrictive assumption which could not be met easily—if at all— by the example employed to demonstrate the relationship. Yet the author gives no quantitative measure of the leeway which may be used or of the penalties to be expected with misuse.

In the following pages, Professor Peach presents the case for designed scientific experimentation simply, briefly, and clearly. Although only the most elementary forms of variance analysis are presented, it will be easy for the reader who has application for them to see the possibility of further methods and to pursue them in the advanced literature which is recommended in the appendix.

In the final chapter the author considers the problem of the organization of a quality-control department from the viewpoint of the qualifications and functions of the personnel. Admittedly, it would be difficult to make specific recommendations for such a department without first considering the other characteristics and organization of the manufacturing unit as a whole. In the main the author confines his discussion to those aspects which will allow the reader to reach his own conclusions concerning a specific application.

In conclusion it should be pointed out that Professor Peach has designed his text to give a maximum of information and aid both to practical men and to students, with a minimum of confusion and discouragement. A complete list of symbols in the introduction, with generally clear statements, definitions, and formulas throughout, assists in this direction, as does an appendix containing an example of each type of problem encountered in the text. The book contains several quality-control shortcuts which will be of benefit to practical users and many remarks on the practice of quality control which will be of interest to the industrial-statistics student.

Numerical Analysis

PLANS have been completed for the establishment of one of the newest units of the National Bureau of Standards, the Institute of Numerical Analysis, at the University of California, Los Angeles, Calif., according to a recent announcement.

One of the giant high-speed electronic computing machines, now under development by the Bureau will be installed at the Institute when completed. These computers will solve problems in minutes that now take days to work out, and will solve in days problems that are now out of the reach of scientists. Design specifications call for high memory capacity and automatically sequenced mathematical operations from start to finish at speeds attainable only with electronic equipment.

The machines can conceivably revolutionize the field of applied mathematics. Of particular importance both to the physical sciences and to technical industries will be the fact that the Institute will be able to set up a mathematical counterpart of an actual situation, which permits the situation then to be studied through relatively inexpensive calculating rather than costly experimentation. Great as has been the progress of the past century, the time has come when many problems of great importance, especially in hydrodynamics, aerodynamics, and meteorology, can only be handled by computers working at speeds measured in millionths of a second.

The Institute has two primary functions. The first is research in applied mathematics aimed at developing methods of analysis which will extend the use of the high-speed electronic computers. The second is to act as a service group for Western industries, research institutions, and government agencies. The service function will include not only the use of the machines for problem solving but also assistance in the formulation of problems in applied mathematics of the more complex and novel types.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

COMPILED AND EDITED BY J. J. JAKLITSCH, JR.

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Pre-Science Schools

ACCORDING to the *Report*, July, 1947, published by the Naval Ordnance Laboratory, as a method of eliminating future shortages of scientists interested in basic research, and of stabilizing the output of engineers from universities and colleges, the suggestion of establishing pre-science schools has been offered. The great strides made in the physical sciences during the last decade have caused a need for changes in the present plan of education used in science schools. Expanding fields call for expanding the educational system. While certain studies have become more specialized, they have also become more dependent on others. The knowledge of physics, for instance, has reached a new high of importance with the engineer. The same can be said of engineering with regard to physics.

The most important reason, however, why some new system of education must be put into effect in science schools is for insurance against any future shortages in trained research and development personnel, and at the same time to prevent the flooding of the market with scientific talent. Such insurance can be attained only through a plan whereby all engineers and physicists are required to take part in basic as well as applied research before entering industry.

Because the fields have expanded so rapidly and become so specialized, more than just a general knowledge is necessary before a man can be accepted as a member of his profession.

In a system of pre-science schools similar to that system used in preparing men for the medical profession, the prospective scientist or engineer, like the premedical, would receive his basic knowledge. Having qualified to enter the profession by successfully completing his courses, the student would then enter the advanced phase of his work—concentrated study and experiment.

A plan of this kind in the United States would minimize the need for training programs aimed at the advancement of personnel in their own and allied fields. It would also tend to stabilize the future supply of scientists and engineers. Interest in the fields' activities would have already been fostered under the educational plan. Further, it would provide the student with an opportunity to know something of all fields before he is forced to choose his specialty.

In some schools there seems to be a definite trend toward such a system, but because of the length of the course required and added expense, many institutions have shied away. Certainly, an extended program does prove unattractive to the prospective student. But long-range advantages would eventually prove its worth.

As early as 1940, many engineering schools had put into effect a five-year plan because of the opening up of new scientific fields. With these fields continuing to broaden, it is reasonable to believe the length and number of courses will increase proportionately.

Whether the pre-science school system is the answer to all the problems cannot be known until it has been put to work. Nevertheless, it is evident that some new plan must be devised. This is one method with definite possibilities which will aid not only in the long-range plans of scientific endeavor in the United States, but which may also aid in the national program to foster interest in basic research in the present.

Science and the Humanities

THE centennial this month of the Sheffield Scientific School of Yale University, the first university division of instruction and research in science to be developed in this country, is coincident with a fundamental reorganization of that School. The undergraduate bodies and faculties formerly divided between the sciences and the humanities have been consolidated into a program of study which, it is believed, will equip the undergraduate to live magnanimously and intellectually in a modern postwar world. The School has now become the Division of Science of the University, responsible for graduate instruction and for the general promotion of science.

A feature of the program is a definite provision for the study of the basic sciences for all undergraduates as a part of a liberal education. Not only will liberal-arts students take more scientific courses but science majors will receive more work in the humanities.

To this end, three new science courses have been constructed. The first course will be devoted to a description of the elements, the forces, and the principles and laws which operate in our material universe. The departments of chemistry and physics will co-operate in this course. The second, composed of astronomy and geology, utilizes the materials and principles of the first course and describes their operation in our universe and in our world. A third course, combining botany, zoology, and psychology, provides a scientific study of living organisms up to and including man himself.

All undergraduate instruction in the arts and sciences will be combined in a single well-integrated program of study under the jurisdiction of a single faculty, and the Sheffield Scientific School will relinquish its undergraduate instruction.

All students desiring seriously to major in the sciences are now under the jurisdiction of the new Yale College faculty of the Liberal Arts and Sciences, the Sheffield Scientific School giving instruction on the postgraduate level only. The postgraduate students in the sciences and mathematics will be registered in the Sheffield School whose faculty will supervise their work and, when the latter is completed satisfactorily, will recommend them to the Graduate School for appropriate high degrees.

This plan of merging the sciences with the humanities is an ambitious one and if successful will provide the College with a program which will be unique in its combination of breadth and thoroughness. The program should prove to be a liberalizing experience to the student and should increase his human understanding.

Steel Production

STEEL production in the first six months of this year greatly exceeded the output of any previous half-year in peacetime, according to *Steel Facts*, August, 1947. For 25 consecutive weeks the industry operated its furnaces between 90 and 97 per cent of capacity, and made a total of 42,267,000 tons of ingots and steel for castings. During that period, users of steel received two thirds as much finished steel as in the entire year of 1940.

However, the halting of production at the coal mines in late June reduced steel operations sharply, marking the fourth time in less than two years that steel operations had been interrupted by the need for conserving coal and coke because of idleness on the part of coal miners. The prompt resumption of mining indicated that there was still a good chance for the steel industry to set a peacetime record in 1947. The following statistics cover the first four months of this year.

In the first four months of 1947, the automotive industry received 2,984,749 tons of finished steel products, an improvement of 14 per cent over the total shipped during the preceding four months. Shipments to freight-car builders during the first four months of 1947 at 686,553 tons showed an 18 per cent gain over the total steel received by this group in the previous four months. Finished steel shipments destined for the oil and natural-gas industry during the early months of 1947 were one third larger than during the final four months of 1946. Comparisons with early 1946 shipments are meaningless in view of the major strikes prevailing during that interval.

During the first four months of 1947, jobbers, dealers, and distributors received 3,461,794 tons, 16.9 per cent of total steel shipped. The automotive industry, the largest steel-consuming group, received 14.6 per cent of the total, slightly better than its share of shipments in 1941. Construction received 9.6 per cent of total steel, 8 per cent went to steel for converting and processing, while rail transportation took 7.9 per cent, machinery manufacturers received 5.3 per cent, and contractors' products accounted for 3.7 per cent. Containers received 7.9 per cent of total shipments, electrical machinery and apparatus consumed 2.6 per cent, appliances, utensils, and cutlery received 2.5 per cent, and other domestic and commercial equipment accounted for 2.8 per cent. During this period the industry shipped directly for export 7.0 per cent of total steel shipments.

Finished steel shipments in April, 1947, set a peacetime record at 5,445,993 tons, equivalent to an annual shipment rate of more than 66,000,000 tons, topping any previous peacetime or wartime peak annual output. April sheet and strip shipments also set a record at 1,566,932 net tons, equivalent to an annual rate of more than 19,000,000 tons. This brought sheet and strip shipments for the first four months of this year to 5,934,201 net tons, a 62.3 per cent rise over the 3,783,331 tons shipped during the strike-bound months of early 1946. The ratio of hot-rolled sheet and strip shipments to total products shipped during the first four months of 1947 improved to 14.4 per cent from the 1946 average of 14.1 per cent. Cold-rolled sheet and strip shipments comprised 11.1 per cent of the early 1947 total, as compared with 11.0 per cent in 1946.

Hot-rolled sheet shipments in the first four months of this year at 2,379,150 tons were up 5.5 per cent or 123,602 tons over shipments during the preceding four months.

Cold-rolled sheet steel shipments during the first four months of 1947 were up 122,792 tons over the 1,629,484 tons shipped during the final four months of 1946.

The improvement in steel shipments to the auto industry is reflected by the fact that the 423,237 trucks produced during the first four months of 1947 comprised the largest number of trucks produced in any four peacetime or wartime months. At the same time, the 314,372 automobiles shipped by the auto industry in April was the largest monthly total since July, 1941. Shipments of all types of motor vehicles in April, 1947, totaling 422,782 units, were 5 per cent below the average monthly rate in the 1929 record year.

Gasoline-Injection Engine

A GASOLINE engine for use on heavy commercial vehicles, in which a gasoline-injection unit replaces the conventional carburetor, has been introduced by John I. Thornycroft and Company, Limited, Basingstoke, Hampshire, England, according to ***Engineering***, August 1, 1947.

Advantages claimed for gasoline injection are: Better volumetric efficiency, brought about by the use of large-bore induction pipes and the absence of the carburetor choke; a hot-spot is not required; better distribution and atomization of the fuel; better control of the mixture within the throttle range; and the use of cold air drawn in from outside the head.

The gasoline-injection engine has six cylinders, with a $4^{1}/_{8}$-in. bore and 6-in. stroke, giving a capacity of 7880 cu cm. It is of monobloc construction, the cylinders and crankcase forming a single casting.

The cylinder heads are designed to accommodate the injectors as well as the spark plugs. The injectors are "let-down" into the inlet ports so that the nozzles are approximately $^{1}/_{4}$ in from the undersides of the valve heads the top of each injector being just outside the valve-spring diameter. From Fig. 1 it will be seen that the inlet port is unusually large; even so, the head has been designed so that a water space is provided between the inlet and exhaust ports for each cylinder in order to insure adequate cooling of the valve seats. The water-cooled exhaust manifold is bolted to the near-side faces of the cylinder heads and the cooling water flows from the cylinder heads to the manifold and thence to the radiator header tank. The main object of the water-cooled exhaust manifold is to reduce the amount of heat transmitted to the fuel-injection pump, which is located just beneath the manifold, and thus avoid vapor locks. The water-cooled manifold also keeps the underhood

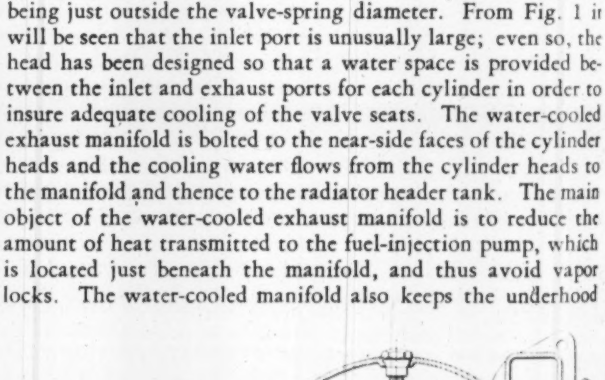


FIG. 1 SECTION THROUGH CYLINDER HEAD AND ONE OF THE PISTONS

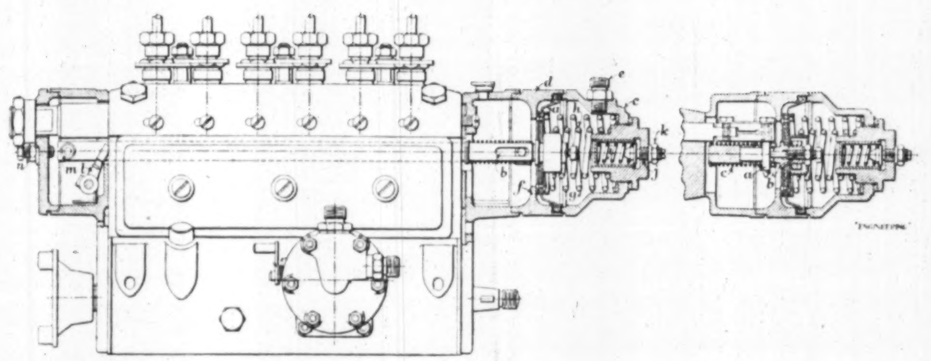


FIG. 2 SECTIONAL DRAWINGS OF CONTROLLER

temperature low and thereby assists in the prevention of vapor locks in the service pipes leading to the fuel-injection pump. Special attention has been paid to crankcase breathing; air is taken in through two Vokes air filters located on top of the valve covers and then passes through the valve-gear chamber, the tappet gear, and the sump to a large-diameter breather pipe fitted with an Amal flame trap, and thence into the induction manifold on the atmospheric side of the throttle.

The fuel-injection equipment was developed in conjunction with C.A.V., Limited, Acton, London, W.3, and consists of an injection pump and injectors, automatic mixture control, excess-fuel device for starting, feed pump, and the usual filter. The injectors are of the spring-loaded poppet-valve type which open at approximately 367 psi. Basically, the injection pump is a standard unit as used on commercial-vehicle oil engines and it is fitted with plungers having a diameter of $7^1/_2$ mm and a stroke of 10 mm, there being a separate plunger for each cylinder. It is fitted with a modified camshaft having eccentric cams which provide a longer injection period, while in order to give greater accuracy of control, the spill helixes of the plungers have a smaller pitch than that used for oil engines, the control rod having a proportionately longer travel. The pump is secured to a bracket bolted to the near side of the engine and it is driven directly by the timing chain. The fuel-pump drive also serves to drive the ignition distributor which incorporates an automatic advance mechanism.

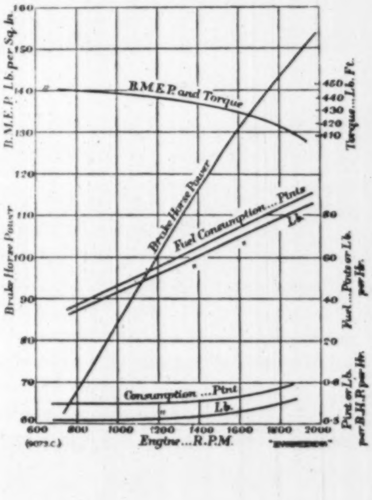
The mixture strength is determined by using the depression in the induction manifold to influence the delivery from the fuel-injection pump. This is accomplished by the mixture controller which consists of a leather diaphragm fitted to the rear end of the control rod, one side of the diaphragm being sealed from the atmosphere and connected to the induction manifold while the other side is open to atmospheric pressure. Fig. 2 shows sectional drawings of the controller. The leather diaphragm *a* is secured at its center to the end of the pump-control rod *b;* it is clamped at its periphery between the diaphragm chamber *c* and the stop housing *d*. The diaphragm chamber *c* is connected to the induction manifold through the connector *e* while the left-hand side of the diaphragm is open to the atmosphere. Thus the force tending to move the diaphragm to the right is equal to the induction depression multiplied by the effective area of the diaphragm. Movement of the diaphragm, and therefore of the control rod, to the left increases the fuel supply to the injectors and the travel in this direction is limited by the diaphragm stop *f* which is integral with the housing *d*. Conversely, movement to the right decreases the fuel supplied to the injectors, but movement in this direction is opposed by the three springs *g*, *h*, and *i*, housed inside the chamber *c* and arranged to make contact with the diaphragm progressively during its travel to the right. In Fig. 2, the diaphragm is shown in the position for full load when the manifold depression is at its lowest, and in this position only the outermost spring *g* is in contact with the diaphragm. As the throttle is closed, the subsequent reduction in pressure in the manifold causes the diaphragm to move to the right against the spring *g* with a consequent reduction in the quantity of fuel delivered by the pump until eventually the diaphragm makes contact with the center spring *h*. From here on the pneumatic force acts against the two springs *g* and *h* causing a decrease in the rate at which fuel delivery is reduced for a given change in manifold depression. When the manifold depression approaches that obtained at idling speed, approximately 18 in. of mercury, the diaphragm makes contact with the innermost spring *i*, known as the idling spring, thereby giving a further stiffening of the spring rate and limiting the travel of the diaphragm to the right. The position of the idling spring, and therefore the idling speed, can be adjusted by the screw *j* and the locknut *k*, while the positions of the springs *g* and *h* can be adjusted by the insertion of shims.

The diaphragm is connected to the control rod in such a manner that the maximum-fuel setting of the pump can be altered and the mixture controller overridden in order to obtain excess fuel for starting purposes. The control rod is moved by the lever *l* which is housed in a small casting fitted to the forward end of the pump and is actuated by a control located in the driver's cab. When the lever *l* is moved it makes contact with the roller assembly *m* fitted to the control rod and moves it to the left, the excess motion of the control rod over the diaphragm being absorbed by the spring *c*. The travel of the control rod to the left, however, is limited by the adjustable stop *n*.

The engine has a compression ratio of 6.92 to 1, which gives a compression pressure of 175 psi and an explosion pressure of 650 psi at 1400 rpm. The curves in Fig. 3 give some idea of the engine's performance.

The engine was fitted to a vehicle having a gross weight of 22 tons and the consumption figures obtained from extensive

FIG. 3 GASOLINE-INJECTION-ENGINE PERFORMANCE CURVES



road tests averaged 6.2 miles per gal at an average speed of 25.9 mph. It is interesting to note the corresponding values for a 100-bhp 6-cyl oil engine, having a compression ratio of 16 to 1, a compression pressure of 562 psi, and an explosion pressure of 963 psi at 1400 rpm. This engine develops 100 bhp at 1800 rpm and, under similar conditions, the fuel consumption was equivalent to 8.25 miles per gal. The average speed, however, was only 16 mph. From this comparison it would seem that the gasoline-injection engine should prove advantageous where high average speeds and quick acceleration are required.

Building Technology

A NEW Division of Building Technology, it was revealed recently, has been established at the National Bureau of Standards.

By no means a finished organization, the new division is made up of a number of sections and parts of sections which have come to be exclusively concerned with various phases of building technology. It is felt that a unified attack on building problems can be more effectively achieved by concentrating these sections in a single division, though they cut across the classical lines of physics, chemistry, and engineering.

The nucleus of the new division consists of five sections: Structural engineering; fire protection; heating, ventilating, and air conditioning; exterior and interior coverings; and codes and specifications. The structural engineering section will deal with the strength, stability, and stiffness of buildings and the structural elements of buildings. The fire-protection section will continue its work on fire resistance of building construction, the fire hazard of building contents, and fire-detecting and extinguishing equipment. Heating, ventilating, and air-conditioning systems and heat transfer through materials and constructions will be the responsibility of the heating and air-conditioning section. The exterior- and interior-coverings section will handle roofing and waterproofing; floor, wall, and ceiling finishes for buildings; and, in general, the chemical and physical properties of bitumens. The codes and specifications section will carry on work on building, plumbing, safety codes and standards, building fixtures and service equipment, and construction and maintenance practices.

While much of the work to be carried on will be primarily for the benefit of other governmental agencies, the results should be useful to the entire construction industry and it is intended that they shall be made available for the purpose. In addition, research problems of interest to the industry as a whole, particularly where no other research facilities are available, will be undertaken to the extent that this can be done.

Italian Zinc Works

AN Italian factory said to be the cleanest and most dust-free zinc works seen by investigators in Europe or America is described in a British report (PB 52855) now on sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C. The plant is reported to be the largest and most modern zinc factory in Italy.

The report gives details of zinc production and fabrication as well as by-product recovery processes. Subsidiary products are sulphuric acid, cadmium, copper, and cobalt.

The factory was built in 1936 at Porto Marghera in Northern Italy. Its original capacity of 30 tons of zinc per day was boosted during the war to the present output of 45 tons.

According to the report, the plant is unusually well equipped. Main units of equipment are Humboldt roasters, a contact sulphuric-acid plant, an electrolytic zinc plant with 20 and 30-ton Siemens-Halske induction furnaces for melting cathode zinc, New Jersey refluxers for refining zinc, a zinc-alloy plant, die-casting machines, a rolling plant, extrusion presses, a zinc-dust plant, electrolytic copper and cadmium plants, and a cobalt smelting plant.

The factory's unusual cleanliness is attributed by investigators to superior construction and emphasis on dust suppression. Buildings are of generous size and height, without pillars or supports in floor areas. For example, the electrolytic-zinc cell room is housed in a single building about 60 ft high with an unimpeded floor area of 310 × 75 ft. All buildings are fitted with overhead traveling electric cranes.

All points likely to permit the escape of dust, such as bin discharges and roasting-furnace exits, are fitted with hoods leading to dust filters, the report states. Containers for weighing and conveying ore are totally enclosed, material being fed in through telescopic tubes.

In spite of the factory's high maintenance and housekeeping standards, the investigators found that little attention was paid to accident prevention. Many examples were seen of poorly guarded and completely unguarded machines. Some employees wearing sandals were seen handling a broken carboy of fuming sulphuric acid. Men were observed working with molten zinc without goggles, aprons, or spats.

Operation of the factory is described in detail, with numerous diagrams, flow charts, and photographs.

Pouring Molten Metal

MOLTEN metal is now poured from foundry ladles by means of power industrial trucks. This is accomplished with a ladle mounted on a base equipped with built-in sleeve pallets and a truck having a rotating head and fork. The driver controls all movements of the truck and also operates the ladle from his platform at the rear of the machine.

The problem in many foundries has been to transport molten metal rapidly from cupola to pouring floor in order to conserve heat and expedite production. Power trucks have been used to carry the metal, but in ladles to be picked up and poured by other means. The new ladle and system provide for direct transport and pouring and are said to be in successful operation.

The ladle is supported on trunnions in a frame of welded steel plate. It is 29 in. in diameter unlined. Two sleeve pallets are welded into the base of the frame. Sleeve pallets similar to

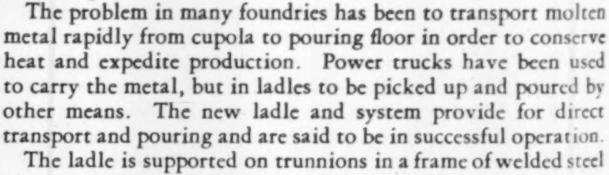


FIG. 4 FORK TRUCK EQUIPPED WITH FOUNDRY LADLE

these have been built into standard-type skid boxes and scoops used for handling foundry materials on ordinary-type fork trucks.

The truck is an Elwell-Parker Electric Co. standard unit of 4000 lb capacity. The rotating head was designed originally for use with a semicircular steel apron for manipulating heavy cylindrical objects. It can pick up such a load from either vertical or horizontal position, transport it any distance, rotate it, and raise or lower it. In the equipment used by the foundries, a fork is bolted to the rotating head. The fork engages the sleeves in the base of the ladle which is held firmly in position for tilting and pouring.

In a typical foundry installation metal from the ladle is poured into a gang ladle consisting of six small independent units which pour into molds automatically when an operator presses a button.

Capacity and flexibility of the truck with the new-type ladle is reported to insure faster economical production with safety.

Further, the rotating head is detachable, and the fork itself can then be attached directly to the truck's elevating mechanism, thus providing all the basic features of the standard fork-type truck for a wide range of purposes.

New Fleet

THE July, 1947, issue of *Logistics* reveals that the Navy Department is slowly unfolding the blueprint for a radically new fleet, designed for attacking cities and land bases rather than fighting other ships. Navy logistics will have to be altered accordingly.

Instead of a battleship, a heavily armored guided-missile ship that can take a pounding to get home powerful attacks on cities and industrial centers hundreds of miles from the coast is planned.

Instead of a cruising ship, it will be a fast-raiding ship firing a barrage of big rockets in bombardment of shore points.

In place of the carrier, there will a be fast intercepter ship with pilotless aircraft to destroy enemy missiles aimed at America. Carriers as known today may be employed as a "coastal defense" several hundred miles off home shores.

Instead of a destroyer, there will be an "attack-killer" class which would have high speed, automatic-firing guns, and plenty of antisubmarine equipment.

Submarines may become specialized for cargo-carrying, scouting, attack, ice patrol, and atom-weapon launching.

The future warship may have few exposed personnel and instruments. It is quite possible that no man will be in sight at battle stations under way. The new types will incorporate lessons of the atom-bomb test at Bikini and the ice menace of the polar regions.

Thickness Gage

A NEW instrument, the Reflectogage, utilizing supersonics for thickness measurement and flaw detection, has been announced by Sperry Products, Inc. With the new instrument thickness of metals and other materials can be measured where access from only one side is available. Maximum error in measurement is said to be less than 2 per cent of the thickness of the material.

Thickness of tubing and flat parts, between 0.005 and 0.300 in. can be read directly from the face of an oscilloscope screen. Indirect reading of the thickness of parts up to 4 in. can be accomplished with slight calculation.

A quartz-crystal searching unit is applied to the oiled surface of the material and the oscilloscope pattern observed by the operator. A vertical deflection of the oscilloscope trace will indicate resonance of the sound beam within the material. The position of the vertical deflection along the horizontal axis is determined by the resonant frequency and is thus related to thickness. When thin pieces are being tested, this thickness is read directly from the superimposed calibrated screen. A different screen is used for each type of material and for each of four thickness ranges.

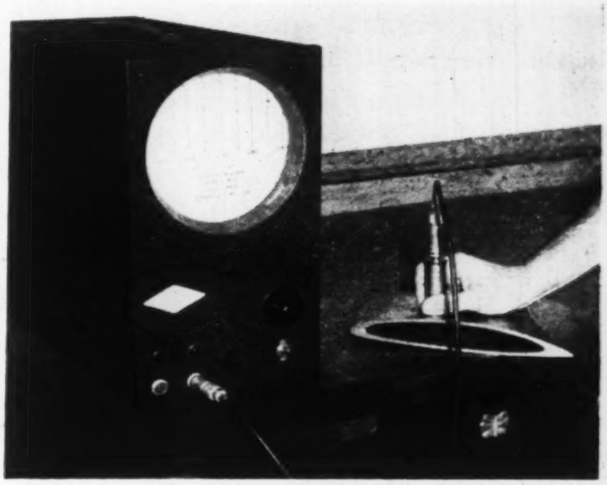


FIG. 5 THICKNESS-MEASURING GAGE

The gage is likewise readily adaptable for the production-line testing of thin pieces, bonded or clad materials, and for internal defects or separations.

European Technical Books

THE current status of technical-book publishing in Europe is summarized in *Science*, July 18, 1947, in an article by James S. Thompson, executive chairman of the board, McGraw-Hill Book Company, Inc., New York, N. Y.

Mr. Thompson reports that as in the United States, World War II has released a vast flood of energy and funds for research in Europe. Just before Mr. Thompson left England, the British government had announced the appropriation of £250,000 (to rise later to £350,000) annually for research in mechanical engineering. In Sweden new plans were announced for coordination of bibliographical material on research. In France new publications, including one on research in nutrition, were discovered, and Switzerland is newly acclaimed in technical publishing.

GREAT BRITAIN

In Great Britain an American feels thoroughly at home in attempting to appraise the technical-publishing situation. The paper shortage, the lag in numbers of scientific personnel, the surge of new subject matter to be published, and the postwar revival of book output are, in varying degrees, similar to our own problems.

International collaboration among scientists and the potential results for publishers are emphasized in current meetings.

According to Edmond Segrave, editor of *The Bookseller*, British book publishers in the period 1939–1946, inclusive, reflect in the statistical record a trend toward technical-book developments similar to that in the United States. In 1939, out of 14,904 books published, 1753 were classed as technical and scientific. In 1946, out of 11,411, there were 1434. The most significanct gains were in the fields of engineering, mathematics, technical handbooks, and veterinary science, farming, and stockkeeping; the greatest declines, in botany, horticulture, and agriculture; medicine and surgery; and geology.

Over-all figures of British book production show the effects of the war. For the years 1939–1946, inclusive, these are: 14,904; 11,053; 7851; 7241; 6705; 6747; 11,411.

Shortages of labor and materials, emphasized by the fuel crisis, continue to plague the industry and cause frustration in the effort to meet the great postwar demand for new books, particularly of a technical and educational nature.

FRANCE

The record of intellectual production to a total of nearly 9000 volumes in 1946 is more than any year since 1938 and double the low period of Occupation in 1941. Science and technology have maintained a steady, if not impressive, rate.

Reports indicate that demands for technical books exceed supply and that new subjects are being covered. It is felt that there is a strong tendency for English to become the second language in France.

SWITZERLAND

In Switzerland an impressive record of developments in new book publication has occurred since 1938. Grand totals of 2162 and 3949 for the years 1938 and 1945, respectively, include for science totals of 239 and 472, or slightly more in percentage of growth than for the nontechnical fields. Officials in both publishing and bookselling believe this growth will continue.

HOLLAND

In Holland 1938 publications totaled 6172 and in 1939, 6554. In 1944 only 1847 titles appeared and in the following year, 2436. It is officially estimated that for 1946 the 1939 total will be repeated and also that the number of translations will be increased. Statistical reports for 1939 show that in scientific and technical subjects total numbers of titles issued were as follows: geography, 102; physics, 199; biology, 85; anthropology, 143; physical training, 96; and psychology, 126. In 1939, of the total of 730 translated works, 421 were from the English and 144 from German sources.

ITALY

Carlton Washburne, director of the U. S. Information Service at Milan, reports that many Italian publishing firms were damaged by air raids. Besides this, the shortage of paper and electric power considerably hindered the continuance of publishing, and the division of Italy in two parts further complicated the situation. As soon as the war ended, the Italian publishers immediately started supplying the country with the cultural equipment necessary for the reconstruction. Thanks to the help of the Psychological Warfare Board of the Allied Forces it was possible to overcome the initial difficulties due to paper shortage. Today paper production is almost normal but its cost has greatly increased (about 1:63). At the same time, printing and other costs have increased 1:50, while the capacity of absorption of the market does not permit an increase in sale price of more than 1:35, and generally even less (25–30 times).

From 1938 the general total of 9736 publications descended in 1945 to 4068 units (the lowest figure being the total of 1795 units for the year 1944), and, though complete information on 1946 is still missing, it seems that the total of 1945 has not been surpassed. In 1945, however, the proportional number of technical and scientific books issued (1336) marks a little progress in comparison with that of prewar years (33 per cent of the total, instead of the constant prewar percentage of 30).

SWEDEN

Extensive industrial utilization of scientific research is an outstanding current development in Sweden, and plans for publication of results in monograph form were recently announced.

Acta Polytechnica is the name of the new periodical and, since it will be published in English, French, and German, worldwide circulation is planned. As a nonprofit enterprise, its circulation will be largely on an exchange basis. It will aim to present the most important contributions made by Swedish scientists in engineering research. Unique among its features will be inclusion of library index cards.

Of the 5298 books published in Sweden in 1939, 2284 were technical, medical, and scientific. In 1945 the total was 5509, including 2319 in these categories.

BELGIUM

An orgy of spending immediately following the liberation resulted in overexpansion of book publishing and distributing facilities in Belgium, and the necessary rebound is affecting book publishing. Since few technical books are produced here, the authors preferring French imprints, since the trade association has no statistical information, and since registration of new books is not required as in other countries, a report is comparatively valueless.

POLAND

Although Warsaw was not visited on this trip, according to the March 29 issue of *The Bookseller*, book production in Poland during 1946 totaled 3248 titles. Although this figure is only 51 per cent of the 1937 total, it nevertheless represents a remarkable achievement, if the technical difficulties and the shortage of paper and plant are taken into account. More than one third of the new titles are in the several branches of science and technology.

CZECHOSLOVAKIA

Conditions of restoration in Prague are different from those in any other country visited. An official of the Ministry of Information reported that in 1946 approximately 8000 titles were published, but the percentages of technical books and of pamphlets were not indicated. The great total was due to the fact that during the six-year "blackout" (1939–1945), nothing was published, and since only a few books appeared in the period 1934–1939, an enormous thirst and backlog was created. It was assumed that in 1947 the total would equal that of the preceding year.

In the Ministry of Education and among native industrialists and several active book dealers it was evident that educational and scientific literature from the United States was in active demand among the Czechoslovakian people.

GERMANY

A brief visit to General Clay's headquarters on June 1, 1947, permitted discussion only of general policy on translations from English and contractual relations between the American Military Government and the publishing industry. Until there is a peace treaty between the United States and Germany, direct financial agreements between German and U. S. publishers become violations of the Trading With the Enemy Act. In view of the extreme shortage of paper and the priority involved in book needs for the general public, it is unlikely that problems of translation of U. S. technical books into German will be under consideration for a considerable period in the future.

DENMARK

Conferences with Nils Bohr of the Research Laboratory of Applied Physics and Henrick Dam, of the Biological Laboratory of the Technical High School indicated interest in attempts to develop, through both memberships in professional societies and the exchange of literature, closer relationships between Danish and U. S. scientists.

Publications emanating from research work in pure and applied science in Denmark, as well as volumes reflecting the developments in the social sciences in this part of the world, are providing an important new literature.

Figures for scientific works published in Denmark in 1939, 1940, 1945, and 1946 are 492, 438, 396, and 449, respectively.

NORWAY

Publishing in Norway is distinctly for the large number of works in English. A unique feature of one of the new books by Tanum is the inclusion, in a series of vertical marginal notes for the Norwegian whose bilingual ability is limited, of the translation of key words.

Publishers as well as operators of two outstanding book distribution agencies of the Scandinavian countries are of the opinion that until Norwegian authors have been able to complete research work which was stopped during the war, there will be few original technical manuscripts for publication. Similarly, Norwegian publishers are operating under a handicap due to paper rationing, shortage of labor, and worn-out machinery.

Book production, prewar and current, is reported as follows: 1938, 1233 titles, 16 technical; 1939, 1429 titles, 25 technical; 1945, 1437 titles, 26 technical; and 1946, 1893 titles, 21 technical.

Radiant Heating

A NINE-STORY student-apartment building now under construction on the campus of the Georgia School of Technology, Atlanta, Ga., according to A. M. Byers Company, will provide architects and engineers their first opportunity to study the differences between radiant and convector heating systems in a multistory building.

One wing of the structure will be heated by means of wrought-iron pipe coils concealed in the concrete floor slabs and the other wing by conventional-type convectors.

It is reported that this is the first multistory building ever to incorporate both radiant and convector types. Both the architectural and engineering departments at Georgia Tech plan to study the systems when they are functioning. Operation costs, as well as performance data, will be recorded.

Of reinforced-concrete construction, the building contains about 63,000 sq ft of floor space. The radiant-heating pipe, fabricated in the form of sinuous coils, is embedded in the concrete structural floor of each story, each room having a separate coil equipped with a balancing valve. About 83 tons of wrought-iron pipe were used for the radiant-heating coils as well as all hot-water supply and return mains and runouts in the convector heating system.

The principles involved in applying radiant heating to multistory structures have virtually the same relationship to those involved when conventional radiator-type systems are used in buildings of more than one story in height. Basically, the only physical difference between radiant and conventional hot-water heating systems is the size of the heating elements—in radiant heating the entire floor becomes a large low-temperature heating panel, while in other hot-water systems, small high-temperature elements are used. About the only unusual feature in the use of radiant heating for multistory buildings is the introduction of slightly different mechanical problems in the over-all hydraulic system.

While specific details are lacking, it is known that radiant-heating systems have been used in England and Europe with considerable success for many years in buildings as high as 18 stories and having large floor areas.

The Georgia Tech apartment is expected to reveal accurate data on differences between radiant- and convector-type heating because construction is identical for the areas in which the two types of systems will be used. The only factor that may have some bearing on performance characteristics is exposure. The radiant-heated wing faces south and the conventionally heated wing is exposed to the opposite direction. Heat losses for the entire structure were calculated at 1,500,000 Btu. Minimum outdoor design temperature is 10 deg.

Resurfacing Areas

NUMEROUS improvements have been noted in materials developed to simplify many problems of repairing or resurfacing areas subjected to wheel or foot traffic. An article by R. L. Meyer, United Laboratories, Inc., in the August, 1947, issue of *Industry and Power*, describes products that need only mixing with water before spreading.

Two major problems must be solved in the majority of floor-resurfacing projects: (1) Selection of materials having strength adequate for the loads involved, and (2) scheduling the work so as to offer the least amount of interference to normal factory operations. Other problems involve resistance of flooring material to wear, ease of cleaning, fire resistance, waterproofness, resilience, and appearance.

Since earlier types of floor left something to be desired, recent years have seen the development of various asphalt mastic materials for floor repair and for new construction. Installations totaling millions of square feet demonstrate that mastics can provide a superior, long-lasting surface. Plastic resurfacers have been developed in packaged form to eliminate variations in the materials, formulas, and application methods. Asphalt mastic can be inexpensive since removing or chipping the old base is not necessary. Correctly mixed and applied, the mastic surfaces are designed to improve with use and to envelop small metal particles that are frequently the cause of surface deterioration. These products are usually applied in thicknesses from 1/8 to 1/2 in. over wood, concrete, steel, or brick. Where directions are followed, a satisfactory bond to the original surface is secured, and the mastic may be drawn out to a feather edge. Also, when well compacted, repairs with such mastics are ordinarily stable under normal factory loads. Traffic serves to further compact the wearing surface and to keep the floor smooth.

Added advantages sought with plastic floor surfaces are: Higher coefficient of surface friction, reduced slipping hazards when floors are wet, sparkproof performance, high electrical resistance, and fire retardance. With the addition of a waterproofing membrane, mastic floors can be laid to prevent leakage to rooms below. When resistance to acid attack is required special types are available. Plastic floor materials are not limited to interior work since the materials are resistant to weather and do not crack as a result of expansion or contraction.

Exact procedures followed in making repairs with mastic products are similar regardless of the type of floor involved. The first requirement is a sound base. On concrete, brick, or similar materials, all loose spalls are removed and holes over

$^1/_2$ in. deep filled with grout. Next, the floor is cleaned of all oil or grease spots, moistened with water, and a bonding cement scrubbed into the surface. After the bonding coat is dry, the mastic is mixed and spread over the area prepared. Finishing operations are similar to those for a concrete floor and the mastic may be troweled to a smooth surface. When the substructure permits, a $^1/_2$ to 2-ton power roller may be employed to compact the mastic after the floor is set, but before it dries completely.

Wood floors require only one change in procedure—in the type of bond employed. After the weak boards are replaced and holes patched, a metal binder is installed to insure a firm bond between the mastic and the subfloor.

Asphalt mastic materials are not recommended for floors subjected to constant contact with quantities of oil, grease, lard, fats, cream, milk, ice cream, sugar syrups, blood, gasoline, naphtha, or other asphalt solvents. Neither should they be installed over a base that is perpetually wet, moist, cold, or so damp most of the time that it cannot be dried out sufficiently to allow the mastic floor to set before being placed in service—however, occasional contact with oil or grease will not be harmful. Equipment having small casters or sharp-edged legs will mark or dent mastic the same as they will linoleum, rubber, tile, or other resilient flooring. Rolling will, however, reduce the tendency to mar.

Transonic Airplane

THE Douglas D-558 "Skystreak," a jet-propelled transonic research airplane, built by the Douglas Aircraft Company, Inc., El Segundo, Calif., for the U. S. Navy, established a new world-speed record of 650.6 mph on Aug. 25, 1947, over the three-kilometer course at Muroc Army Base, Calif. This was 9.9 mph faster than the record of 640.7 mph set on Aug. 20, 1947, by the same airplane and was the first time new records have been established in such quick succession. Conceived early in 1945, the Skystreak is to be used to explore the aerodynamic forces acting upon airplane and controls in the transonic region of speeds between 550 and 900 mph.

See also "Developments in High-Speed Aircraft," by E. H. Heinemann, on pp. 805–812 of this issue.

The airplane is powered by a new G.E.-Allison J-35 turbojet engine rated at 4000 lb static thrust.

Featuring an 11-stage compressor and single-stage turbine, the J-35 is an axial-flow-type jet engine. Air is scooped directly into the front of the engine and is then compressed in a straight line through a series of 11 stages into 8 combustion chambers.

The burning fuel-air mixture, rushing from the combustion chambers at a temperature of 1500 F, strikes the blades of the turbine wheel to provide mechanical power for operation of the compressor. At full power the turbine wheel rotates at the rate of 7700 rpm. Gases unused in operation of the turbine wheel escape rearward at high velocity through a tail pipe to provide the forward thrust for the airplane.

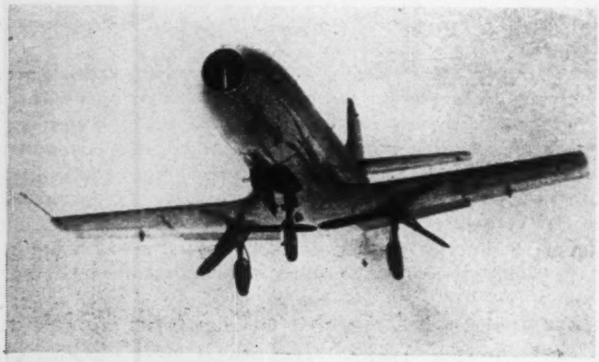


FIG. 6 JET-PROPELLED TRANSONIC AIRPLANE TAKING OFF

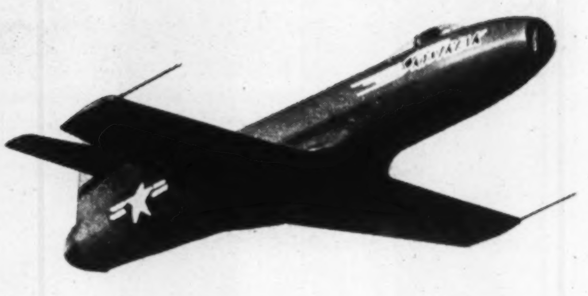


FIG. 7 TRANSONIC AIRPLANE IN FLIGHT

This axial-flow design is responsible for the small frontal area of the engine. It is 39.5 in. in diameter.

The critical speed of the wing is the principal item limiting the speed of most aircraft. For this reason the Skystreak's ten per cent thick wings, with low aspect ratio (4.15) and small area (150 sq ft), were advantageous at the speeds attained. Its gross weight with normal fuel (230 gal) is 9750 lb. It has a wing loading of 65 lb per sq ft for take-off and 56 lb per sq ft for landing. It has straight wings 25 ft in span, and is 35 ft long and 12 ft high.

The main fuselage is fabricated of magnesium alloy, while the wing and control surfaces are made of 75S high-strength aluminum alloy. The thinness of the wing made it necessary to design special wheels, tires, and brakes small enough to be completely retracted into the wing.

Though a transonic airplane, its performance characteristics are those of a normal aircraft. It takes off, climbs to service ceiling, performs its level speed runs, and returns to its starting base at all times under its own power.

Fuel (230 gal) is carried inside its thin wings. Wing-tip tanks are provided to increase endurance, range, and altitude in forthcoming phases of the research program.

Equipped with 500 lb of recording instruments, the airplane will carry a man and a power plant in the transonic flight range at varying altitudes during the next two years. Air pressures will be measured at 400 separate points on wing, tail, and fuselage surfaces.

Every safety precaution has been taken, including a special escape method for the pilot to bail out at high speeds at high altitudes. The cockpit or forward section of the aircraft is jettisonable. In emergency the pilot breaks the nose compartment clear of the rest of the airplane and then, after its speed is reduced, bails out in a relatively normal fashion.

The cockpit is pressurized to maintain normal conditions at high altitudes. A pressure type "G" suit gives additional protection against blacking-out during sharp turns or pullouts.

Special oxygen equipment is carried as emergency provision to safeguard the pilot in the event of loss of cabin pressure at high altitudes.

A cooling and heating system maintains an even temperature in the pilot's cockpit during the changes of altitudes and speeds.

Special harnesses, pads, and padded head supports are provided to give the pilot maximum possible protection against the violent sharp jolts resulting from flying in the transonic range.

The three-kilometer (1.863-mile) speed course on Rogers Dry Lake at Muroc, used for the record flight was surveyed by the U. S. Coast and Geodetic Survey to an accuracy of one part in one million.

The course and the timing methods used are in complete conformance with existing Federation Aeronautique Internationale rules. The F.A.I., Paris, France, is the official international society for all aeronautical record trials. Its United States representative is the National Aeronautic Association.

A 12-ft-wide black oiled strip spread upon the beige-colored lake floor with two large circles at each end of the east-west course acts as a surface marker for the pilot. Colored smoke at each end of the course offers additional guidance.

Four passes, two in each direction to compensate for any wind, are required over the speed course. These must be made during the same flight. An average of the four passes is the official time. The record attempt must be made after a take-off and must be followed by a successful landing. At least two successful take-offs and landings must have been accomplished prior to the record attempt. The existing record must be exceeded by at least 5 mph.

At no time is the pilot permitted to fly above 1310 ft. When flying over the 1.863-mile "flash" course and 1640 ft on either side of it he must fly below 246 ft.

The 1640-ft points at each end of the measured run are where observers are stationed to determine that the aircraft is below 246 ft.

To make sure that the permissible altitude of 1310 ft is not exceeded on turns, two pylon planes hover at 1310 ft in the turning area which covers about 25 miles on either end of the course. Two more planes, each with sealed barographs aboard, patrol to the south and north of the course at 1310 ft.

The runs are photographed by intricate timing cameras mounted on concrete stands at each end of the course. Synchrometer clocks photograph the time and the aircraft simultaneously to one thousandth of a second. Cameras operate at 500 frames per sec and special lenses maintain a sharp image to infinity.

Jet-Propelled Flying Boat

THE first SR/A1 jet-propelled flying-boat fighter has recently been completed by Saunders-Roe, Limited, East Cowes, Isle of Wight, England, and was flight-tested July 30, according to *Engineering*, Aug. 8, 1947.

The maximum speed and other details of performance are not available for publication; however, the airplane was not flown at much more than about 400 mph. The take-off was noticeably short and it was reported that the control of the airplane was good.

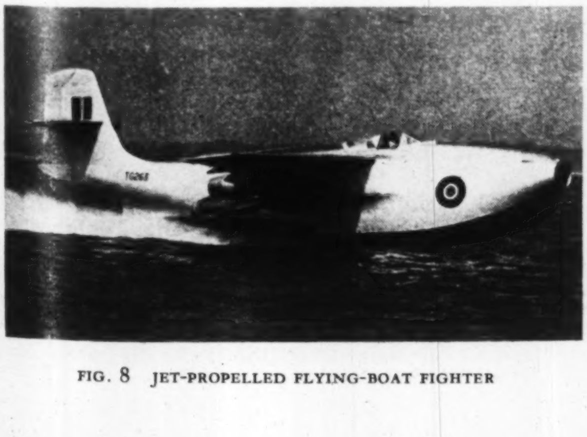


FIG. 8 JET-PROPELLED FLYING-BOAT FIGHTER

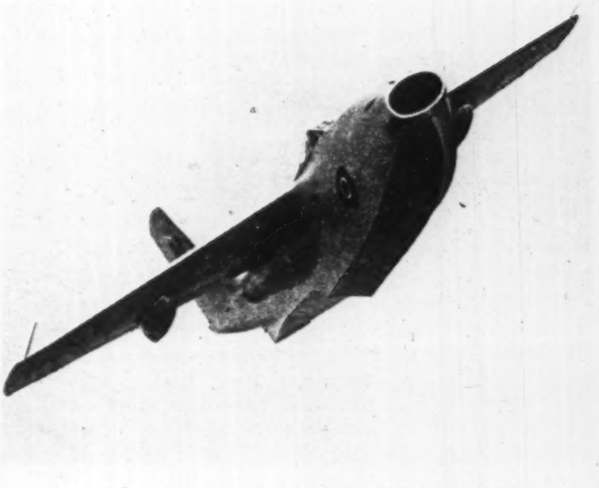


FIG. 9 JET-PROPELLED FLYING BOAT IN FLIGHT

A flying-boat fighter is said to be superior to a land plane in that it does not require an elaborately prepared base. Any convenient sheltered stretch of water provides the base, which is easily camouflaged and not readily made unusable by the enemy. The base is established quickly, and in the case of a sea-borne landing, a base for fighter cover may be close to the scene of operations.

It was formerly difficult to build a flying-boat fighter to utilize these advantages because of the proximity of the propellers to the water with a piston-type engine, but the jet engine eliminates this difficulty. In the SR/A1 the two Metropolitan-Vickers F 2/4 gas-turbine engines and the armament have been placed in the hull to permit the use of a high-speed profile for the wing. The single seat is situated above and toward the forward end of the jet engines, which are placed side by side. The air intake for the engines is at the bow of the hull, the required "ram" effect being best achieved in this position; and the outlets are located one on each side of the hull, aft and below the trailing edge of the wing. Fortunately, it was found that the width of the hull, as determined by hydrodynamic considerations, was approximately equal to the width required for the two engines placed side by side. Tank testing indicated that the bow would be free from adverse effects of spray, and this has been borne out in the trials with the full-size flying boat. If sea spray does, by chance, enter through the air intake, no serious damage is done. The wing is of single-spar construction with chord-wise stiffening, and carries two floats which are retracted in flight. They hinge inward and upward, by hydraulic action, and simultaneously the floats proper revolve in the supporting arms, so that when fully retracted they present a smooth form. The over-all length of the flying boat is 50 ft, the over-all height 17 ft, the beam of the hull 6 ft 10 in., the span of the wing 46 ft, and the wing area 415 sq ft. The aspect ratio of the wing is 5 to 1.

Each jet engine consists of a ten-stage axial-flow compressor, an annular combustion chamber, and a single-stage turbine coupled to the compressor, all of which are arranged axially and permit a small frontal area. It is believed that the side-by-side arrangement of the engines will give good flight characteristics on one engine; and that, at certain low thrusts, economy of fuel will be achieved by using only one engine. Each engine is 3 ft 2 in. in diameter, 13 ft 3 in. in length, and weighs 1750 lb dry. An electric starter motor has been provided for the first airplane, but a small two-stroke gasoline-engine starter will also be given a trial. The maximum speed of the gas turbine is 7700 rpm, and the idling speed is 2600 rpm, which corresponds to a thrust of less than 250 lb. The designed static-thrust rating of the engine is 3500 lb at take-off, 3300 lb for the climb, and 3000 lb for cruising; for these thrusts the fuel consumption in pounds per hour per pound thrust, is 1.05 lb, 1.05 lb, and 1.00 lb, respectively.

The armament of the SR/A1 consists of four 20-mm cannon situated in the bow just above the air intake.

Peacetime Atomic Pile

CONSTRUCTION began on Aug. 11, 1947, at Brookhaven National Laboratory, Upton, L. I., N. Y., of the first peacetime atomic pile for use in fundamental research in medicine, physics, biology, chemistry, and engineering.

Work was commenced with ground-breaking ceremonies held in the presence of members of the United States Atomic Energy Commission, guests and Laboratory employees, officers of The H. K. Ferguson Company, which will construct the pile, and trustees and officers of Associated Universities, Inc., which operates the Laboratory.

In an interview preceding the ceremony, Dr. Lyle Borst, who heads the group which designed the pile, and who will also be in charge of operating the pile when completed, explained that the new atomic pile is expected to be completed and in operation by mid-1948. Though not the largest atomic pile, he explained, it will contain a number of improvements that will make it the most flexible research pile in the world.

The pile is designed primarily for use in research, and will provide many experimental facilities not available in other piles now in operation.

Among others, there will be facilities for bringing neutron beams out of the pile, for irradiating biological tissues, and for making studies of the characteristics of neutrons. Provision has been made for special research on materials used in connection with the construction and operation of atomic piles, and also on the engineering problems involved in atomic-power production.

In general form, the Brookhaven pile will be similar to the Oak Ridge pile, except that the neutron density will be several times greater. It will be able to produce radioactive materials as does the Oak Ridge pile. Such materials from the pile will be used in research primarily at Brookhaven, but they will also be available, when not obtainable elsewhere, to research institutions throughout the Northeastern States, in the territory served by Brookhaven.

The pile, which will be air-cooled, will be housed in a building approximately 120 ft long × 100 ft wide, and more than six stories in height. The building will be flanked by two wings, each nearly 100 ft long, which will contain laboratories. With its associated laboratories, the pile will cost approximately $10,000,000.

Though operation of the pile will be so nearly automatic that one man could safely care for it, present plans call for two to three men per shift. The pile is designed to operate on a schedule of seven days per week, 24 hr per day.

Dr. Phillip M. Morse, Brookhaven director, pointed out that the Brookhaven National Laboratory and its equipment are to be devoted to atomic research, which is expected to provide new knowledge of the structure of the universe, and help speed peacetime developments of the Atomic Age.

The pile is the first large item of atomic equipment upon which construction has been started at Brookhaven Laboratory. Other equipment to be constructed include a "hot" laboratory for use in research on radioactive materials, a large cyclotron, and a Van de Graef generator. Under preliminary study is a huge proton accelerator capable of producing a beam of atomic particles at 10 billion electron volts, with which atomic scientists hope to be able to create matter out of energy. (Further information concerning Brookhaven National Laboratory appears in the April, 1947, issue of MECHANICAL ENGINEERING, pages 321–323.)

Commissioner Sumner T. Pike, of the United States Atomic Energy Commission, in a brief address on the occasion of breaking ground for the first Brookhaven reactor, said: "It is probably fair to say that our principal concrete responsibility is that of producing atomic weapons. This may be our principal responsibility for a long time to come; I hope not.

"When we try to visualize other applications we see immediately a multitude of possibilities—power, treatment of diseases, improving industrial processes, bigger agricultural crops, and so on through a long list. We are working hard on the problems connected with the production of power. Radioactive isotopes are being shipped to many centers and are being used for a wide variety of pure and applied research ends, but as we look at each one of the myriad possible applications, we find two things missing; (1) we don't know enough, and (2) there aren't enough qualified people to find out the things that we need to know.

"The Atomic Energy Commission feels that its major problem both for the short and long run, which overrides that of specific development in particular fields, is the more general one of learning more basic facts and training more able people who will be able to take up and enlarge research. Of course we cannot do this alone. We would be quite helpless unless universities took these problems as theirs. We can, however, be of some use in providing the tools and stimulating people in the nuclear field.

"On the outskirts of Chicago is the Argonne National Laboratory with 29 co-operating universities. In Oak Ridge, Tenn., is the Clinton Laboratory with a group of 14 universities tied into it. Both of these are in operation and well on the way toward fulfilling the functions to which they are aimed.

"Here today at Brookhaven we are making a tangible start in the third of these national laboratories designed particularly for the universities of the Northeastern part of the United States.

"From these laboratories we hope the people will learn and disseminate information which will be useful to science and industry, but overriding that, we hope we can assist the universities in training people who can advance the use of these new tools so that as the frightfulness of these discoveries wears away, their ultimate place in the great body of useful human knowledge can seem as natural and as easy to understand as the radio in your living room."

Air-Power Status

A SUMMARY of the general air-power situation prepared by the Aircraft Industries Association, appears in *The Martin Star*, August, 1947. It is an impartial review of the present status of things aerial and is particularly timely since the Army Air Force, this year (August), celebrated its 40th anniversary.

The article points out that contrary to general public belief and the many discussions concerning the possibility of a "push-button war" in the near future employing guided missiles, war rockets, etc., scientists and technicians, qualified to know, declare that effective long-range use of guided missiles is years off—possibly five, likely ten or fifteen. Research and development of these new weapons, however, must be pushed energetically. In the meantime, during the chaotic period of world adjustment immediately ahead, there is critical need for an interim air force, equipped with improved types of orthodox aircraft.

Top-flight scientists, however, do not underestimate the eventual role of guided missiles; they are impatient with premature and ill-informed talk about them.

One form of guided missile is equipped with a device which automatically seeks out a target having certain characteristics. Other types may have the control preset before launching, or the control may be remote (by radar or wire).

One of the three basic types is used whether missiles are designed for air-to-air—rockets or projectiles launched from one plane to another; air-to-surface—any projectiles fired from planes at ground targets; surface-to-surface—for example, the German V-2's; and surface-to-air—antiaircraft rockets.

The first German vengeance weapon, the V-1 buzz- or robot-bomb, was used in 1944 on the London area. Powered by a ramjet engine, the V-1 was a pilotless aircraft, 25 ft long, with a wing span of 17 ft. It weighed 5000 lb of which 1000 lb was fuel. Operating at a maximum range of 150 miles, the V-1 developed a speed of about 400 mph. Guided by a compass and kept on an even keel by a gyro, the buzz-bomb packed a warhead of 2100 lb.

Of the 8000 V-1's launched against England, nearly half were shot down by the R.A.F. and antiaircraft, or ran afoul of barrage balloons. Another 25 per cent either exploded at launching or went wild because of faulty mechanism. More than 2000, however, did blast the metropolitan area, causing extensive damage and loss of life.

The V-1 was a faulty weapon, primarily a terror device but as soon as its nature was understood and means found to combat it the people rallied.

The German V-2, a rocket projectile, roaring 50 or 60 miles above the earth at a speed of 3600 mph from a point about 190 miles distant on the Continent, was next launched on London. Weighing 14 tons at launching, the V-2 burned four tons of alcohol and five of liquid oxygen in its jet engine to develop a thrust of about 60,000 lb.

Damage inflicted on London and later on Antwerp, was heavy. In all, about 2000 V-2's bombarded London and 1600 were sent against Antwerp, but enormous German outlay in effort and resources was not warranted by the military results obtained. The V-2 was a weapon of Nazi desperation. Months, if not years, from perfection, it was thrown into the conflict by Hitler as a stopgap for the failure of the Luftwaffe to cope with Allied air might.

Vengeance weapons were the most spectacular guided missiles to come out of the war, but both sides employed other specially designed contrivances.

GERMAN

Fritz-X was an air-to-ground armor-piercing 3000-lb bomb, guided by radio or wire.

HS-293, a glide bomb, also launched from an aircraft, had a range upward of six miles. It was a miniature, pilotless plane, with a warhead of 1100 lb. It was used with fair success against Allied shipping in the Mediterranean.

A variety of antiaircraft devices—Rhinedaughter, Ruhrsteel, Butterfly, etc., were controlled ground-to-air rockets, lacking in quality and quantity production.

AMERICAN

Azon, a 1000-lb bomb, of conventional type, with radio-controlled tail surfaces was dropped from an altitude of about 12,000 ft. It had its main use against railroads, bridges, and similar transport facilities. Its accuracy had been estimated as some ten times that of the ordinary bomb.

The GB-8, a 2000-lb glide-bomb, equipped with a pair of 12-ft wings, with preset controls and carried under Flying Fortresses, were useful against U-boat pens on the French coast, and against the German cities of Cologne, Salzberg, and Duren, though not on a large scale.

"Weary Willie," stripped-down B-17's and B-24's, loaded with 2000 lb of TNT, were taken into the air by pilots who bailed out when "mother" aircraft assumed control by radio near the target.

The "Bat," an air-launched, radar-homing glide-bomb, equipped with wings, carried a 1000-lb warhead and performed well against Japanese shipping in the Pacific.

American developments, too late for war use, include an improved version of the German V-1 and "Gapa," a ground-to-air antiaircraft rocket.

Other devices are being developed by industrial laboratories under the supervision of the armed services and the National Advisory Committee for Aeronautics. They comprise whole families of guided missiles of all types, guinea pigs from which improved models will evolve. Most are still secret, but the "Tiamat" is typical of many of them.

A 14-ft, 600-lb rocket, the Tiamat, reaches speeds of 600 mph. Preset control of three tail fins sends it toward its target. It is also equipped with "seekers," reacting to heat, light, noise, and other characteristics of the chosen target.

Another is the "Gorgon," an intercepting guided missile, made of plywood, with a seeking head, and developing a speed of 500 mph.

Little can be said about these projects beyond the fact that so far achievements do not bear out predictions of an impending era of push-button warfare. If war does break out in the near future, guided missiles will play a much larger part than during World War II—but their use would be mainly as extra-long-range artillery.

Some of the major engineering obstacles confronting rocketeering are the following:

Fuel. Granted perfection of some super-heat-resistant alloy for rocket bodies, there would remain the serious problem of propulsion. Fuel accounted for nine of the V-2's tons. It was consumed in the first 60 sec of flight. The remainder of the missile's course was free flight. Horizontal flight of transoceanic missiles would require such great quantities of fuel that the rocket would have to have fuel compartments nearly a mile long—and such a rocket couldn't be launched. Even fired over an arched trajectory, the rocket would need such immense amounts of fuel that it would be aerodynamic folly to consider the thing.

Power Plant. Rocket engines for practical push-button warfare are in about the same stage as liquid-cooled engines of World War I aircraft, according to Count Werner von Braun, who developed the V-2. After his capture, von Braun said that Goebel's propaganda ministry thought much more highly of the V-2 than did German scientists. The problems of use of liquid or solid propellants, methods of fuel burning, and heat dissipation, were barely touched by German and subsequent experiments. Ultimately atomic power may solve both fuel and engine problems but no reputable technologist believes its efficient application to rocket propulsion is probable for years to come.

Controls. At their present state, preset or automatic controls are too erratic to risk with guidance of giant missiles over vast distances. The rockets envisioned would be astronomical in cost. They would have to be used with utmost thrift—particularly if carrying warheads of atomic explosive. Automatic or radio control grows more complicated with each additional mile of range. When any slight mechanical flaw would send them miles off course to destroy a mountain or cow pasture, no nation could afford to employ them. As for radar guides, upper-air exploration has shown that cosmic-ray flurries can seriously scramble such equipment. Even on the surface, when sun-spot activity is high, electronic communications of all types—including the relatively simple telephone—become freakish. Moreover, man-made static can jam radio controls.

Cost. According to A.A.F. General George C. Kenney, billions of dollars will be expended before a 5000-mile guided missile can be brought to the test stage—and that means time as well as money. After that, the first production rocket would cost only about 7 million dollars, with expense scaling down to around $270,000 apiece when quantity output had been achieved. Whether we or another nation first develops such long-range rockets, the programs will require comparative consumption of energy, resources, and time, regardless of the particular monetary system, or lack of it.

The tendency to think of orthodox aircraft and streamlined interim air forces as obsolete is dangerous in the extreme. The threat today, and for the immediate tomorrow, is from long-range airplanes. Capable of operation under all kinds of weather, with ranges already passing the 100,000-mile mark, such aircraft in quantity are our best defense, the only safeguard of world peace.

At the same time, we must support the most extensive program possible in the field of guided-missile research and development—a program second to none.

Transmissometer

An electronic instrument developed at the National Bureau of Standards for measuring atmosphere visibility promises to be an important addition to airport safety equipment. The new device, called a transmissometer, was designed to reduce the human factor in visual estimates of distance, particularly in foggy weather. The transmissometer not only provides an indication of visual ranges but also seems readily adaptable for another important phase of aviation, the control of high-intensity airport approach lights, as well as control of fog dispersal equipment.

Visibility of objects or lights depends on the transmission of light by the atmosphere. A correlation therefore exists between the transmissometer readings and the maximum distance at which markers or lights can be seen by a trained observer. If the atmosphere is uniform, this distance can be determined directly from the readings, giving a more complete indication of visibility than general terms such as foggy, hazy, and clear which have been frequently used in describing atmospheric conditions.

The transmissometer consists of a light transmitter, a phototube receiver, an amplifier, and an indicator. The distance between the transmitter and receiver may be varied depending on the particular application; in tests, distances up to 4000 ft have been used successfully. The amount of light reaching the receiver from the transmitter is determined by the fog density or other atmospheric conditions in a direct line between the two pieces of equipment. The light falling on the receiver actuates an electronic circuit whose output is an electric current which varies directly as the amount of light received.

Investigations are now under way to determine exactly the scope and usefulness of the transmissometer to aviation. Five units, installed at the Joint Landing Aids Experiment Station, Arcata, Calif., are being used in an extensive study of fog dispersal methods and high intensity approach lights. The instruments have also been in use at the CAA Experimental Station, Indianapolis, Ind.; at the Naval Air Test Center of the Bureau of Aeronautics, for visibility and airport lighting equipment tests; and at the Tiffany Foundation, Long Island, N. Y., under direction of the National Defense Research Council.

A special use of the instrument was indicated during tests at Arcata when it was found that the transmissometer began to give evidence of the approach of fog as much as six hours before any trace could be seen by the human eye. Similarly, it frequently gives indications of the lifting of fog long before changes can be seen.

10,000-Kw Gas Turbine

The results of works tests on a 10,000-kw gas-turbine plant built by Brown Boveri & Company, Limited, Baden, Switzerland, for a power station in Southeastern Europe, are given in an article by C. Seippel in *The Brown Boveri Review*, October, 1946. The plant is shown diagrammatically in Fig. 10.

Features distinguishing it from its predecessors are the two-stage compression with interstage cooling and two-stage expansion with interstage reheating, two measures which are said to increase the efficiency. A heat exchanger for recovering the exhaust heat is dispensed with, since the installation is intended for peak-load service and low initial outlay was more important than high efficiency.

The guaranteed output of 10,000 kw was exceeded by more than 2000 kw. If the fact is taken into account that space conditions on the test bed did not allow suction and exhaust pipes of sufficient section—the resistances to flow were 167 and 662 kg per sq meter as against 100 and 150 kg per sq meter on site—the rating at the terminals becomes 12,385 and 12,020 kw at suction temperatures of 13.4 and 20 C, respectively. The latter figure denotes the "corrected output." The installation is therefore a 12,000-kw plant based on an air temperature of 20 C.

The measured full-load efficiency at the terminals was 22.24 per cent; with the normal pipe resistance and air at 20 C it would be 23.27 per cent and the efficiency at the coupling 23.72 per cent. An efficiency of 21.6 per cent was guaranteed.

High- and low-pressure admission temperatures are 566 and 573 C, respectively, and lying below the highest admissible limit of 600 C, insure a long-life machine. It is intended to operate the high-pressure turbine at a slightly higher temperature. The measurement of admission temperatures is not easy, due to the nonuniformity of the temperature along the blades. For instance, the hot gas pipe is surrounded by a jacket of cold air which sweeps against the roots of the blades of the first ex-

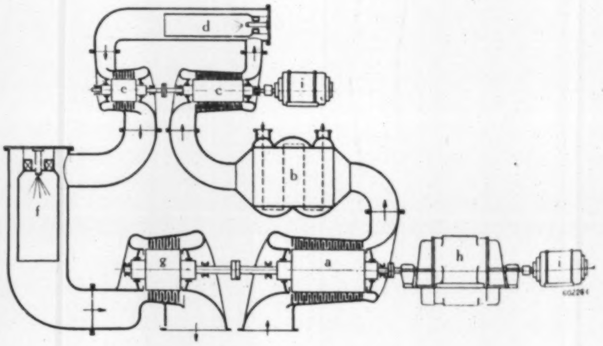


FIG. 10 DIAGRAM OF 10,000-KW GAS TURBINE

(*a*, Low-pressure compressor; *b*, intermediate cooler; *c*, high-pressure compressor; *d*, high-pressure combustion chamber; *e*, high-pressure turbine; *f*, low-pressure combustion chamber; *g*, low-pressure turbine; *h*, generator; *i*, starting motors.)

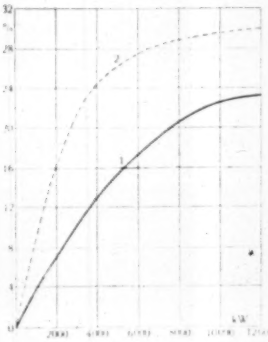


FIG. 11 EFFICIENCIES IN RELATION TO LOAD

(1, Plant without heat exchanger, generator on low-pressure shaft; 2, plant with heat exchanger, generator on high-pressure shaft.)

pansion stages. The temperatures are deduced from the heat balance of the heat liberated during the combustion process. Losses due to incomplete combustion of the fuel and radiation of the combustion chamber are ignored. They represent maximum possible values of the mean gas temperature and are the most rigorous criterion for the efficiencies. The temperatures measured by thermocouples lie a few degrees lower.

The rate of air delivered by the compressor at full load is 26.5 kg per kwhr as against 55.7 kg per kwhr for a 4000-kw single-stage plant. From this it will be evident that both the low-pressure and high-pressure sets are much smaller than a single-stage machine of the same rating. For 10,000 kw a two-stage set is actually less expensive than a single-stage machine, the speed of which would have to lie below 3000 rpm, due to the large volume of gas.

The test results permit the adiabatic efficiencies of the compressors and turbines to be worked out. It is a simple matter to determine, at least approximately, the product of the turbine and compressor efficiencies, but not so easy to establish the individual values. This product is 79.2 per cent for the high-pressure set and 75.4 per cent for the low-pressure stage at full load, which corresponds to mean turbine and compressor efficiencies of 89 per cent and 86.9 per cent for the high-pressure and low-pressure stages, respectively.

The gas volumes are such that the low-pressure set can be run at 3000 rpm, thus permitting direct coupling of the generator. The low-pressure turbine, apart from driving the low-pressure compressor, furnishes the entire useful work and thus utilizes a large part of the available adiabatic drop. As a result, for a given admission temperature the exhaust temperature is relatively low, which in the absence of a heat exchanger is of advantage. Considerable attention has been paid to the question of the optimum compression and expansion gradients of multiple-stage turbines. In the case of two-stage compression and expansion with a large heat exchanger it has proved to be more advantageous to take the useful power from the shaft of the high-pressure turbine instead of from the low pressure stage. When an alternator is coupled to the low-pressure set its speed remains the same at all loads. In consequence, the air volume also remains constant, i.e., the temperatures are too low at low loads and the corresponding efficiencies therefore poor. For a peak-load machine, which when in operation at all, is usually more or less fully loaded, such a characteristic can well be tolerated.

In machines equipped with heat exchangers, however, it is more advantageous to couple the alternator to the high-pressure turbine shaft to obtain good efficiencies also at low loads.

The turbine is governed by variation of the quantity of fuel injected into the two combustion chambers. At full load and a suction temperature of 13.4 C, heat is liberated at a rate of 31.4 $\times 10^{-6}$ kcal per hr in the high-pressure combustion chamber and 13.7 $\times 10^{-6}$ kcal per hr in the low-pressure combustion chamber; with a suction temperature of 20 C the corresponding values would be 30.95 and 13.5 $\times 10^{-6}$ kcal per hr. With diminishing load only the low-pressure flame is reduced at the beginning, with the result that the admission temperature of the low-pressure turbine drops, whereas that of the high-pressure stage is maintained. When the load is so far reduced that this low-pressure flame approaches its limit of instability, the high-pressure burner is regulated. From this point onward the admission temperature of the high-pressure stage also decreases.

The power developed by the high-pressure turbine and that absorbed by the compressor must balance. This is achieved automatically since an excess of power causes the speed to rise slightly, whereupon the consumption of the compressor increases and equilibrium is restored. Conversely, a drop in power causes a slight speed reduction. At full load, equilibrium is established at 4000 rpm. With diminishing load the admission temperature and pressure of the low-pressure turbine first drop, thus increasing the adiabatic drop available for the high-pressure turbine, which accelerates to 4200 rpm. As soon as the high-power burner is reduced the speed diminishes, attaining 3860 rpm at no load.

A centrifugal governor fitted on the low-pressure shaft controls the two burner orifices. The oil servomotors of the burners have springs adjusted to insure the burners opening and closing in the correct sequence. As a precautionary measure a governor is also provided on the high-power shaft, but this only has to intervene should the speed rise too high, which, however, has so far never been the case. Its function is to relieve the high-pressure burner. The temperature limiters are also considered solely as emergency devices, which do not intervene under normal service conditions.

The governing of the 10,000-kw turbine is illustrated in Fig 12. The speed of the low-pressure set, which drives the generator, is kept constant by means of a standard Brown Boveri centrifugal governor. If, for example, the speed of the low-pressure set falls, then the governor increases the pressure of the relay oil. The fuel valves are opened a little more, the quantity

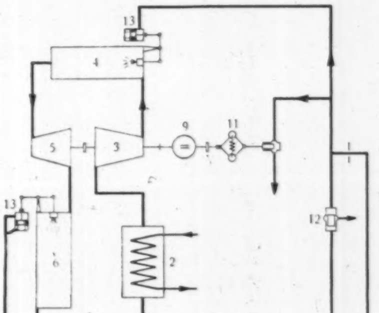


FIG. 12 DIAGRAM SHOWING GOVERNING OF THE 10,000-KW GAS TURBINE

(1, Low-pressure compressor; 2, intercooler; 3, high-pressure compressor; 4, high-pressure combustion chamber; 5, high-pressure turbine; 6, low-pressure combustion chamber; 7, low-pressure turbine; 8, generator; 9, starting motor; 10, centrifugal governor; 11, speed limiter of high-pressure set; 12, pressure transformer; 13, piston for regulating fuel valve.)

of fuel admitted to the combustion chambers increases, and the low-pressure turbine is brought up to the required revolutions. The speed of the high-pressure set is not regulated; it is independent and corresponds to the power equilibrium between the turbine and the compressor. Should it increase to an inadmissible value, the speed-limit device comes into action and reduces the amount of fuel injected into the high-pressure combustion chamber.

The governor of this two-stage combustion turbine is said to function very rapidly and with great accuracy.

Science Program

THE first report of President Truman's Scientific Research Board, directed last October to study the scientific research and development of this country, was completed recently by John R. Steelman, assistant to the President and board chairman.

The program calls for an expansion of scientific research entailing annual expenditures of at least one per cent of the national income by 1957. At the current national income rate that would mean more than $2,000,000,000 per year, or twice as much as is now being spent. Half the money, the board said, should be provided by the Federal Government and the rest by industry, education, and privately financed research organizations.

The following principal recommendations were made:

(1) Increase expenditures for research and devlopment "as rapidly as we can expand facilities and increase trained manpower," and devote at least one per cent of the national income to such activities in universities, industry, and the Government by 1957.

(2) Place heavier emphasis on basic and medical research, quadrupling expenditures for basic research and tripling those for health and medical research in the next decade.

(3) Expand the Federal Government's support of basic research in universities and nonprofit institutions at a progressively increasing rate, reaching an annual expenditure of at least $250,000,000 by 1957.

(4) Establish a national science foundation to make grants in support of basic research, with a director appointed by and responsible to the President and with a part-time board of eminent scientists and educators as advisers, half to be drawn from outside the Federal Government and half from within it.

(5) Develop a program of Federal assistance to undergraduate and graduate students in the sciences as an integral part of an over-all national scholarship program.

(6) Develop a program of Federal assistance to universities and colleges for laboratory facilities and scientific equipment as an integral part of a general program of aid to education.

(7) Establish a committee, composed of the directors of the principal Federal research establishments to assist in the coordination and development of the Government's own research and development programs.

(8) Make every effort to assist in the reconstruction of European laboratories "as part of our program of aid to peace-loving countries," giving such aid on terms requiring the maximum contributions toward restoration of free international exchange of scientific knowledge.

President Truman, in an accompanying statement, said that "Mr. Steelman's report, entitled 'Science and Public Policy: A Program for the Nation,' makes a comprehensive survey of the present position of the United States in the field of science. It outlines a broad program over the next ten years that should greatly advance the nation's position in scientific research and development.

"The position of world leadership this nation occupies is due in large part to the fact that in a few generations we transformed our pioneering way of life into a modern industrial economy resting on the principle of scientific and human progress.

"We must constantly enlarge the boundaries of scientific knowledge in order to continue to provide the benefits of full production and full employment, and in order to protect our democracy from the dangers it faces in an uneasy world.

"The fact that only a thin trickle of scientific knowledge is today reaching us from other countries constitutes an emergency and a challenge. To meet this challenge, we must promote the rapid growth of basic research, the cross-fertilization of ideas among our scientists, and the maturing of a new generation of scientists who will think boldly and daringly.

"We must concentrate on training young men and women who not only can handle technological devices, machinery, and equipment, but who understand the laws by which these devices function. We must educate young people who will be able not only to apply known scientific principles to the peaceful development of new techniques in industry, agriculture, and medicine, but who will have the creative ability and the scientific training to discover new basic principles themselves.

"These are matters that should be carefully considered by scientists, educators, industrialists, and legislators, as well as by private citizens."

Reports From Germany

Paint Industry

A COMMERCIAL and technical survey of the German paint industry, including information on formulas and manufacturing processes, is contained in a British report (PB-66130) now on sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C.

The report covers the processing of drying oils, urethane oils, emulsion-type coatings, finishes for vehicles, wood finishes, industrial finishes, and manufacturing and testing methods. Twenty-seven German plants were visited.

It was found that the use of substitute materials had given rise in some cases to a reduction of quality in the finish though not always of performance value.

Owing to the shortage of linseed oil and other drying oils, the Germans, during the war, utilized emulsion-type coatings extensively for camouflage purposes, walls and ceilings, building interiors and exteriors, and for most other civilian requirements. Emulsion paints were little used in Germany before the war.

One of the more important emulsion paints was a series of polyvinyl acetate resins made by I. G. Farben at Hoechst and sold under the trade name "Mowilith." In emulsified or dispersed form the resin can be used as a paint medium drying by evaporation only and giving, in certain circumstances, tough adherent films which have particular value as interior and exterior protective coatings.

An interesting and promising development, it is reported, was the application of the urethane reaction to drying-oil systems. Because of the shortages of drying oils, the manufacture of urethane oils did not advance beyond the research stage. Urethane, formed by a reaction of an isocyanate with an alcohol, was discovered by Wurtz in 1848. The Germans experimented with isocyanates and results surpassed their expectations.

Urethane oils are quick-drying and harden rapidly. The oils are said to have excellent pigment-binding properties, high resistance to swelling in water, are resistant to acids and alkalies, have a low wood penetration, and give gloss finishes with a minimum of coats. Details on the preparation of these urethane oils are given.

The report includes the formulas and methods used in manufacturing "Shambit," a corrosion-resisting coating composition. The "Samka" process, a novel method of heating used in the manufacture of synthetic resins, and the "Atephen" lacquer system, used for the preparation of chemically resistant linings for metal tanks, are also described in the report.

Heat-Treating Textiles

A German patented heat-treating process for carrying out various chemical reactions on textiles by passing the material through a molten-metal bath is described in a report (PB-22337) now available from the Office of Technical Services.

The German patent covering the process, states that heat-treatment of textile chemical compounds is generally accomplished with heating plates, drying cylinders, heated air, or with heated water vapor. A different method is here proposed wherein the textile material, previously treated with the proper dye, water-repellant, or crease-resistant compounds, travels on guide rollers through a bath of molten lead, tin, or alloys of lead, tin, bismuth, or cadmium for a given period of time. The temperature of the treatment may be regulated below or above 100 C depending on the metal or alloy. The metal bath may be heated by firing or, more advantageously, by electric current. Overheating is not a danger because the metal, being a good conductor, does not accumulate heat.

The liquid metal does not adhere to the surface of the cloth, according to the patent. The process may be used both with moist and dry cloth.

It is claimed that the process eliminates the expense of heating large quantities of air for hot-air treatment, and that it does not entail the heavy heat losses associated with heating plates and drying cylinders. It also requires less operating space than other methods.

Coal Preparation

The United States coal industry may profit by studying German coal-preparation methods and machinery, according to a report (PB-48438) on sale by the Office of Technical Services. Many developments described in the report are considered adaptable to American use.

General engineering and design of German coal-preparation plants are less advanced than in America and England and the plants are very large and overstaffed in relation to output, according to the report. However, some machinery and techniques appear to be of special interest in this country. Among the machines described are dedusting devices, flash driers, conveyer driers, resonance screens, froth breakers, and anti-breakage loading devices.

The report summarizes the main differences between German and American coal preparation practices as: (1) Greater use of conventional jig washers in Germany; (2) presizing of coal before jigging as compared with almost universal jigging of unsized coal in America; (3) treatment of fine coal on jigs in Germany, in contrast with American use of tables, launders, and classifiers; (4) extensive German use of froth flotation; (5) no direct counterpart in Germany as the American wide application of the Chance sand-flotation process, but a more definite German trend to the use of substantially stable suspensions; and (6) loading of the product through bins in Germany compared with the American practice of direct continuous loading from preparation units to transport facilities.

Probably the most striking contrast with current American methods is said to be the widespread use of jig wash boxes for fine coal in Germany and most of Europe. Fine coal is washed on multiple-compartment piston jig boxes, sometimes with feldspar on the screens of the primary washers but generally with a natural slate bed on the rewash boxes. Middlings from the fine-coal jigs are usually put through rewash jigs.

The technique of jigging fine coal is reported to be well developed in Germany and the American industry might profit from an adaptation of this system, particularly in conjunction with tables or launder washers that operate on a stratification principle complementary to jig stratification.

Development of aspirator dedusters has greatly facilitated the German practice of dedusting fine coal before washing and has revived interest in bin drainage. German technologists claim that complete removal of dust not only improves the performance of washers but also greatly increases the rate of drainage. A trend from centrifugal drying back to bunker drainage was noted.

The Germans devised several intensive coal-purifying methods for exacting war uses, especially to obtain superclean electrode coal. These methods included multiple-stage froth flotation, controlled heavy suspension separation, electrostatic separation, acid extraction of ash minerals, and tar-oil extraction of coal matter.

These intensifying processes were applied with widely varying success to make very low-ash coal as a substitute for other carbon materials not available to the Germans. Some of these methods are believed to be of use in the United States in producing low-ash coal to make aluminum-industry electrodes, sugar-refinery carbon and activated carbon, and in the carbide and carborundum industries.

Machine Tools

Combination boring and milling machines and swivel-head vertical milling machines were two of the few new machine tools developed by the Germans during the war, according to a report (PB-63855) on German machine-tool practice for sale by the Office of Technical Services.

The combination boring and milling machines were made to increase precision and save resetting of the work. Work was moved from one set of cutters to another. The cycle was not simultaneous but successive. The investigators found swivel live-spindle headstocks and swivel wheel heads on grinding machines to be more versatile than U. S. models although not as rigid or productive.

In the grinding field, a tendency to build machines with low power for a designated work swing was noted. Ten-inch grinders, for example, would have range for full 10-in., but power, weight, and grinding-wheel capacity would be more nearly comparable to our 6-in. grinders.

At the Gerb Heller Machinenfabrik at Nurtingen the investigators found a giant machine for turn-milling the crankpins and adjacent web faces of Diesel-motor crankshafts. Since the crankshafts were large, it was necessary to use a 40-in-diameter cutter. Plant personnel claimed that the machine, estimated to weigh from 150,000 to 200,000 lb, could finish a crankshaft in 24 min compared with 160 min by previous turning methods.

Iron Castings

Details on manufacturing operations utilized by the German iron-castings industry are contained in two British reports now on sale by the Office of Technical Services.

The first report (PB-63856) is concerned with centrifugal castings as used in the production of cast-iron pipe, cylinder liners, and piston rings; the second report (PB-65665) gives details on the light-castings industry, manufacture of such items as bathtubs, cookers, and other building accessories. The reports include descriptions of melting and cupola practices and information on tuyères, sand equipment, methods of core drying, and enameling.

In the centrifugal-castings industry it was found that the bulk of German cast-iron pipe was produced in three plants. Two of the plants employed the normal Delavaud process; the third used the sand-spun process.

Detailed descriptions are presented on cast-iron and steel-cylinder liners produced in chill molds on horizontal-axis centrifugal machines, cast-iron cylinder liners produced on horizontal-axis machines in sand-lined molds, and steel castings produced on vertical-axis machines in sand molds and in chill molds to show variation from British practice.

In the light-castings industry, it was found that German plant equipment and the products of some plants were good, but that plant layout and labor utilization were poor.

In the foundries visited most of the melting was carried out in cupolas although some use was made of small electric furnaces in the bigger works for small experimental melts and for special-purpose irons. There were also several light-castings factories which had been fitted with side-blown converters for the production of steel and cast-steel shells in permanent molds.

An unusual tuyère arrangement was found at the Deutsche Eisenwerke at Hilden. The plant had four large tuyères approximately 14 × 16 in. which were reduced in size to about $6^{1}/_{2}$ × 16 in. by heaping sand on the floor of each tuyère. Each tuyère communicated with an independent wind box on the outside of the cupola, about 36 in. high × 15 in. wide and 12 in. deep. Control of blast to each tuyère was achieved by a slide which regulated an opening in the center of the wind box. A slight hole and cleaning door was provided in the lower portion of the wind box.

Testing Machine

ENTIRELY new construction principles are embodied in the University of Washington's new 2,000,000-lb tension-, compression-, and transverse-testing machine which was designed and built by The Baldwin Locomotive Works, Philadelphia, Pa. The new machine is housed in the Structural Research Laboratory of the Division of Civil Engineering.

While not the largest in use by industry, the machine is among the largest and is reported to be the largest testing machine in the Pacific Northwest. The machine, weighing 300,000 lb but capable of exerting a force of 2,000,000 lb, incorporates several new features in design which make its steel columns more rigid than has heretofore been possible, thus giving the machine greater accuracy and making it more versatile.

Special flex-plate construction ties the sensitive yoke to the the transverse rigid beam. There are three contacts between the two—the capsule, which acts like a ball bearing and has no vertical stability; the initial load springs, which have no vertical stability; and the flex plates which provide practically no vertical restraint and a maximum of horizontal rigidity.

Another feature is adjustable guides, made triangular in shape, making it possible not only to keep horizontal movement to a minimum but to lock the crosshead in position when required.

The third feature, which makes it possible to maintain the minimum tolerance against horizontal deflections under load, to prevent premature buckling of compression specimens, and to neutralize horizontal components of force, is the flaring of the steel columns from a point about one third of the way from the top to the base of the machine. This affords maximum rigidity or minimum deflection when testing specimens so long that their height forces the columns to function as cantilever beams. It is reported that the machine will have from 300 to 400 per cent greater rigidity than machines of earlier design.

The University plans to devote the machine to special testing research on airplane materials including aircraft wing panels; to various tests for the timber industry; to testing concrete culverts for the state highway department; and to other work for industries of the Northwest.

The machine will take specimens up to 10 ft wide, 20 ft high, and (for transverse testing) 80 ft long. It will enable the research man to test materials for all six forces and six moments.

Wind-Speed Indicator

A NEW portable wind-speed and direction indicator, said to be of high sensitivity, has been developed by S. H. Womack and F. Cordero of the National Bureau of Standards with the co-operation of the Navy Bureau of Aeronautics. This instrument, particularly adapted to use in airplane take-off tests at landing fields, measures wind velocity by means of a propeller forced to head into the wind by a vane. Wind speed is registered on a magnetic tachometer coupled to the rotating propeller shaft, while wind direction is at the same time indicated on a circular scale by a pointer connected to the shaft of the vane.

Accurate measurement of low wind velocities is necessary in

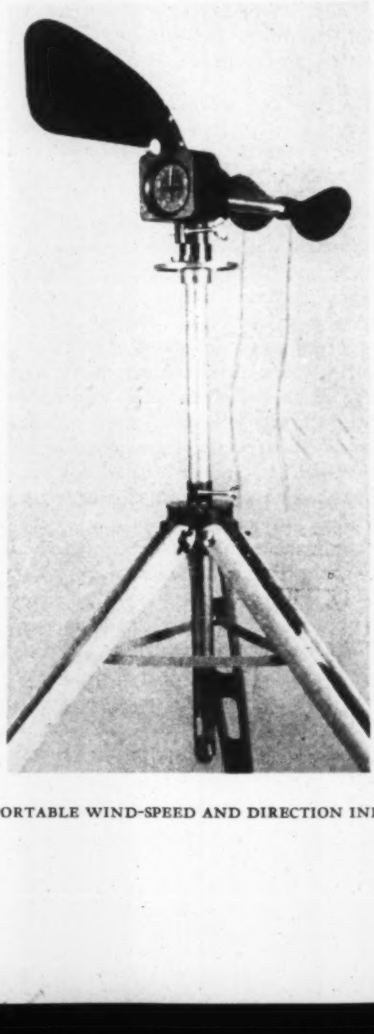


FIG. 13 PORTABLE WIND-SPEED AND DIRECTION INDICATOR

take-off tests of aircraft, since design specifications call for certain standards of performance at zero wind velocity. In practice, a wind speed of zero is seldom experienced. Hence the usual procedure is to record wind velocity at the time of the test and correct the test results to zero wind speed.

Until this wind-speed and direction indicator was developed, the measurement of low wind velocities at landing fields was hampered by the lack of a compact, portable, easily-assembled wind-velocity gage of adequate sensitivity. The portable assembly designed at the Bureau, is light and self-contained, requiring no power, either electrical or mechanical, except that taken from the wind for turning the vane and rotating the propeller. It records both direction and speed of the wind and is easily adjusted for different ranges of wind speed. In addition, it is automatically temperature-compensated, and thus may be used outdoors in all weather.

The instrument consists of an anemometer (or wind-speed meter), a wind-direction indicator, a tripod support, and a leveling device. The anemometer is rigidly attached to the direction indicator, and the two are mounted so that they rotate on a vertical shaft supported by a tripod.

A small wooden propeller coupled directly to a magnetic tachometer constitutes the velocity indicator. The tachometer used for this application is a magnetic-drag instrument, in which the rotation of a small magnet within a conducting cup sets up eddy currents in the walls of the cup. The resulting torque upon the cup, due to the interaction of the induced currents and the field of the magnet, acts against a hairspring to move the pointers on the dial. The modification of the meter, other than alteration of the dial to read knots or miles per hour, consists of the substitution of the propeller-driven shaft for the three-phase synchronous motor that rotates the magnet as the tachometer is ordinarily used.

The meter as modified at the Bureau has a $2^{3}/_{4}$-in. dial with two pointers registering on separate scales. The long pointer makes $3^{1}/_{2}$ revolutions, one for every 10 knots in the instrument, thus giving a range of 35 knots on a scale graduated in tenths of a knot. The short pointer indicates the number of revolutions of the long pointer.

The wind-direction indicator consists of a duralumin vane, a pointer, and a disk graduated in degrees. The pointer, extending parallel to the vane, turns with the vertical shaft to which it is connected and indicates direction.

The shoulder piece of a surveyor's tripod with 5-ft legs is altered to hold a vertical tube housing the rotating shaft of the vane.

Wind-tunnel performance tests with the new instrument are reported to have been quite satisfactory. When the air speed is increased slowly from zero, the vane, if initially displaced as little as five degrees from the equilibrium position, lines up with the wind direction before the propeller starts turning, and does not oscillate abnormally at air speeds up to the full range of indication.

The propeller rotates at a rate essentially proportional to the true air velocity, except at the very lowest speeds, where a slight frictional drag reduces the rate of rotation. Since friction is limited, for practical purposes, to the small amount present in the propeller shaft, the anemometer is very sensitive. In the instruments assembled at the Bureau, wind-speed indications begin at about $1^{1}/_{2}$ knots, and, if the propeller is already rotating, they will continue down to about $^{1}/_{2}$ knot.

Greater sensitivity than that indicated by a pointer revolution every 10 knots is readily obtained, though hardly justified for most uses. Variation in the extent of the air gap between the magnet and the follower cup offers an easy and convenient method for adjustment of both range and sensitivity, and if adjustment below the range obtainable at the closest coupling is desired, this is accomplished by the use of a propeller of suitable pitch angle. From —20 C to +50 C, the effect of temperature on the wind-speed readings is negligible; at —50 C, the error is about 0.5 knot.

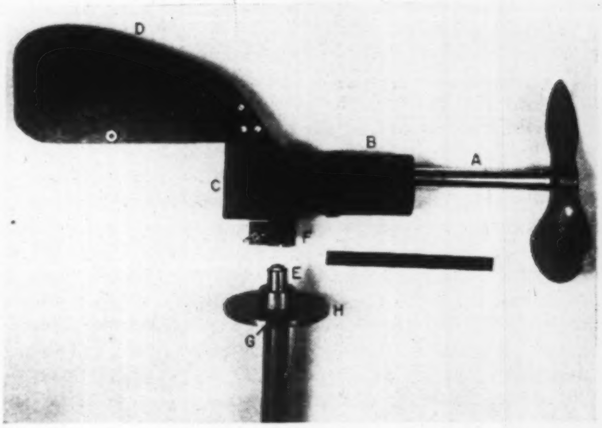


FIG. 14 UNASSEMBLED VIEW OF PORTABLE WIND-SPEED AND DIRECTION INDICATOR

(The anemometer element consists of the propeller, a shaft A, and a magnetic tachometer B, whose dial has been altered to register wind speed. The anemometer may be supported in the bracket C, or it may be held in the hand and operated alone. The direction unit has a wind vane D, which, when connected to the shaft E by means of the clamp F, rotates the pointer G over the direction scale H. The tube K is mounted on a tripod with provision for adjusting the height of the instrument from $5^{1}/_{2}$ to 7 ft above the ground.)

Injection Molding

IN co-operation with Chrysler Corporation engineers, the Hydraulic Press Manufacturing Co., Mt. Gilead, Ohio, has designed equipment for the injection molding of rubber. The machine was described by R. E. Davis at an H-P-M editorial forum held Aug. 15, 1947.

By means of a turbojector, a specialized form of screw feed, it is possible to inject rubber into closed molds.

Some advantages claimed for the process are: Its "hopper" will take rubber in almost any form; feed stock may be removed by strip knives from the "warm-up" or "sheet-off" mills and fed into the injection head, thus eliminating stock-preparation labor and operations such as the making and weighing of preforms; material may be taken directly from the tuber; rubber in rod or strip form may be used directly from storage without warm-up or plasticization; loading boxes and similar devices for charging the mold are entirely eliminated; preheating is eliminated since the turbojector forces stock into a mold cavity at an elevated temperature only a few degrees under mold temperature; higher tensile strength is imparted because the material enters the cavity in a turbulent advancing movement which gives a "knotty" structure to the material, eliminating laminations, strain lines, and stresses; the feed mechanism also acts as a highly efficient mixer of the stock, effecting a virtually perfect dispersion of the chemicals making up the compound; injection under high pressure gives a dense product with no chance for porosity; and flash and excess material is done away with because the precise amount of stock needed is injected into closed molds.

The machine is similar in concept and arrangement to a plastics injection-molding machine. The injection head, or turbojector unit, is mounted on a base incorporating the mold-clamping element.

Material is introduced into the machine in rod, strip, or pellet form near the top of the feed screw (worm), where it is taken into the convolutions of the worm by a masticating action which serves to heat the material uniformly by friction and to further mix it.

The material thus being worked is split into two halves by the baffle gears. This action involves more turbulence and more friction, consequently more heat. By this time the material has been heated to anywhere between 120 and 220 F and is becoming quite plasticized.

Once past the baffle gears, the two halves unite and fill out completely the space between the thread of the worm. Heat is put into the material during the rest of its travel in the mechanism.

When the end of the feed screw (worm) is reached, the material is filmed over the conical end of the worm (which floats against a spring at its other end) and is further heated by an amount dependent upon the thickness of its film.

The film is forced into a circular cross section through the nozzle into the mold. The extrusion temperature must be kept low enough to prevent partial curing of the material anywhere in the mechanism.

The two major sources of heat are: (1) In the baffle-gear section controlled by the baffle-gear cooling water; and (2) at the end of the worm where the material is filmed, controlled by the nozzle adjustment regulating the thickness of the film.

When the mold is full and the injection unit is backed off, there is the problem of locking the pressure of the plasticized material in the worm. This is accomplished in the baffle-gear section by the baffle gears filling the area between the teeth of the worm, and at the end of the worm by the spring seating the worm against the nozzle.

The mechanism readily lends itself to automatic feeding because of the gripping action of the worm on the stock being fed.

In addition, the turbojector unit is supplemented by a tilting cylinder arrangement which moves it to and from the mold.

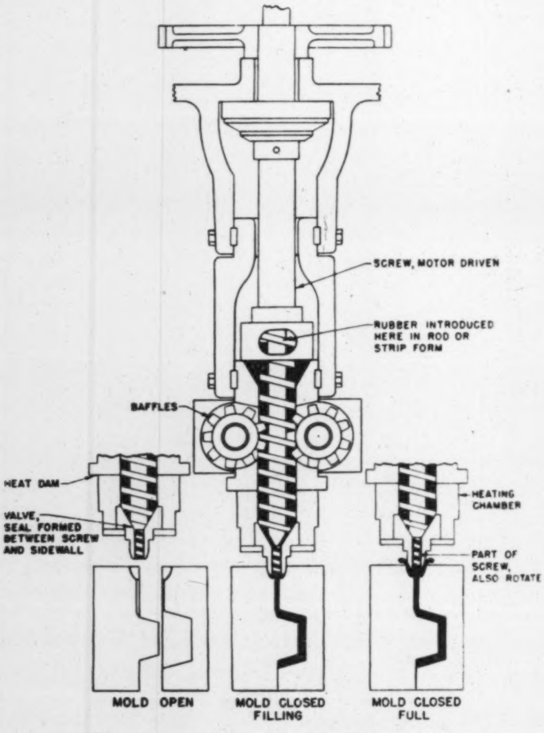

SCREW, MOTOR DRIVEN
RUBBER INTRODUCED HERE IN ROD OR STRIP FORM
BAFFLES
HEAT DAM
VALVE, SEAL FORMED BETWEEN SCREW AND SIDEWALL
HEATING CHAMBER
PART OF SCREW, ALSO ROTATE
MOLD OPEN
MOLD CLOSED FILLING
MOLD CLOSED FULL

FIG. 15 SECTION THROUGH TURBOJECTOR SCREW

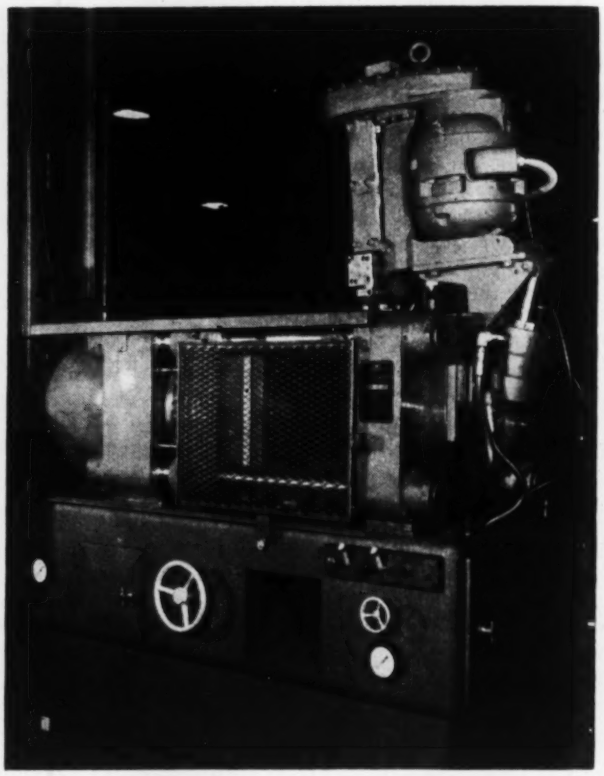


FIG. 16 RUBBER-INJECTION-MOLDING MACHINE WITH 400-TON HORIZONTAL CLAMP

As soon as the mold is filled, the rubber extruded from the nozzle tilts the injection unit slightly, causing an electric contact to momentarily reverse the screw, then stop its rotation. The hydraulic ram which tilts the injection unit reseats the nozzle. This action closes a check valve in the nozzle, preventing the rubber in the mold from backing up through the sprue bushing.

The majority of the turbojector units supplied thus far have been complete machines, mounted on 450-ton horizontal clamps. These machines have a maximum injection pressure of 18,000 psi, and can handle 3 to 4 lb of material per "shot," with parts having a developed area up to 90 sq in.

In looking to the future it appears that high production molding by the injection method will be accomplished by unique setups that will provide means of moving multiple molds or the turbojector unit itself in such a way as to enable the turbojector to function nearly 100 per cent of the time.

This may be accomplished in the following ways: (1) A self-contained machine incorporating a turbojector, main clamp, and turret arrangement with auxiliary clamps. The molds would automatically be positioned at the injection unit for filling while being held by the main clamp, move through several curing stations, an unloading station, and finally up to be filled again. (2) A movable packaged turbojector unit which could travel up and down a battery of compression presses filling each press and not returning until the molded goods were cured and unloaded. (3) A self-contained main clamp and injection unit with facilities for handling the molds in and out of the press. Molds would be filled in this main press and when full, removed to a battery of curing presses for curing and unloading.

Die-Casting Trends

A LOOK at today's trends in die-casting application and equipment was given by Fred C. Ziesenheim, during the editorial forum held Aug. 15, 1947, by the Hydraulic Press Manufacturing Co., in Mt. Gilead, Ohio.

Present die-casting machines are of two types: (1) Submerged plunger injection machines for low-melting-point alloys (lead, tin, and zinc) requiring temperatures up to 800 F or more; and (2) cold-chamber injection machines for the high-pressure casting of high-melting-point alloys (aluminum, magnesium, and brass), 1100 F to 1800 F.

Aside from the injection systems, the functions and structure of the machines are similar, so that either class of machines can be readily converted from one type to the other.

H-P-M now offers die-casting machines in both types of injection systems in rated die-clamping tonnages of 150 ton and 400 ton. A 1000-ton cold-chamber machine has also been built.

Submerged plunger injection machines upon manual initiation can automatically complete each casting cycle, which includes the casting operation, removal of cores by cams or hydraulic cylinders, and the ejection of the casting by bumper bars or by hydraulic cylinder. Cycles may be fast—up to 350 or more "shots" per hour.

Cold-chamber machines require the closing of the die, then the hand-ladling of the molten material into the cold chamber, after which the operator touches a foot pedal and the automatic cycle of metal injection, chilling time, core pulling, and parts ejection takes place. Cycles may range from 60 to 120 or more shots per hour, depending upon the weight of the material being hand-ladled.

Modern machine design has made considerable progress in eliminating porosity, which has meant increased strength of die-cast parts. There are two sources of porosity in castings—shrinkage voids and entrapped air and gases. Effort is made in die casting to overcome shrinkage voids by applying pressure on the casting as it chills in the die. Likewise, entrapped air or gases which cannot be avoided are minimized and compressed in volume by pressure applied on the casting as it chills in the die, preferably to the point where the porosity is not discernible by x ray. Machines then must be capable of applying and holding high pressure within the die cavities.

The trend toward larger zinc die castings, noted before the war, has been reversed. Lighter castings are being made which are assembled into larger-appearing units.

One of the largest aluminum die castings made has been an air-cooled engine cylinder and crankcase unit. The air-cooling fins are thin, long, and spaced fairly close together. The casting weighs 15 lb as cast and 13 lb finished. The dies weigh 14 tons and took 50 men one year to build.

Die-cast air-cooled engine blocks for aircraft and automotive use are said to be entirely feasible and practical. One motor manufacturer has announced a 2-cycle, opposed-piston, air-cooled engine of 125 hp, weighing 150 lb. It consists of five major aluminum die castings and six aluminum pistons and other elements.

Large automobile-body panels and doors have also been considered in both aluminum and magnesium die castings.

Another projected use for aluminum die castings is the master and service cylinders of hydraulic brake systems. Such castings have been used in the aircraft field for years.

Other parts originally switched to die castings because of shortages of iron are now used because they are reported to be better and cheaper. Fluid-drive couplings for automotive use having airfoil blade sections (which will reduce slippage from 10 to 20 per cent) are being developed for production as die castings. Likewise, more efficient car-heater fans are being produced.

Electric-motor manufacturers are turning to die casting for housings, end bells, and the like, as well as for help in improving actual working parts. Copper rotor bars, separate conductor rings, and stamped-steel fan blades have been eliminated in rotors by die casting all of these elements integrally in high-purity aluminum.

The integral-die-cast aluminum rotor provides a light, long-life assembly with no subelements to come loose and cause trouble.

The advantage of die casting over the usual "dunking" (or permanent-mold) method of casting aluminum motor rotors is not only a higher output per man-hour but a much lower reject ratio. This is due again to the application of high final injection pressure in the casting cycle.

Because of the low rejection factor, large rotors are being considered for die casting by many manufacturers. It is difficult to salvage rejects but it has to be done to conserve the

FIG. 17 SMALL ZINC-DIE-CASTING MACHINE

FIG. 18 REAR VIEW OF SMALL ALUMINUM-DIE-CASTING MACHINE

silicon-steel laminations. Saving copper and eliminating its high cost is also a factor. The elimination by die casting of some other structural elements used in motors is also being considered. The building industry is using more zinc die-cast hardware to meet shortages and cut costs. Gas and electric meters and even electric conduits are now made more economically in aluminum die castings.

The method and equipment used for brass die casting can be the same as for the cold-chamber die casting of aluminum. However, due to the metal temperature of 1800 F as compared with 1200 F for aluminum, it is obvious that die life will be considerably less. Die life may range from less than 10,000 shots to as many as 100,000 shots. The most successful brass die castings have been those involving thin-walled sections. However, some large brass die castings, up to 12 and 15 lb, have been made successfully.

An important need for the efficient cold-chamber die-casting of large heavy castings is a method for automatically ladling the molten material into the cold-chamber injection system.

A proposed method under development by the Ajax Engineering Company, Trenton, N. J., is the discharge at uniform rate for a given period of time of hot metal from an electric induction furnace, by utilizing the "pinch pressure" or magnetic flow movement of the hot metal through an orifice or tube about the electric transformer. It is now being adapted to permanent-mold practice where the molds can be transported past the furnace.

The problem of transporting hot aluminum from the furnace to the cold chamber without the metal "freezing" or picking up iron is also a difficult one.

Personal Flying

IN a talk which he gave at a symposium on personal aircraft before the Institute of Aeronautical Sciences in Detroit, recently, Jerome Lederer, member A.S.M.E., chief engineer, Aero Insurance Underwriters, New York, N. Y., said that everyone is in favor of removing danger from personal flying but, like the fight against sin, progress is slow; it often must be forced even when the contributing factors are well known.

According to Mr. Lederer, the predominant safety objectives of aircraft engineers and designers thus far have been: Structural integrity; power plant reliability; reasonable stability; and controllability.

These objectives have been achieved to a great degree, provided the airplane is operated in accordance with maintenance and operating instructions. Yet fatal accidents continue to occur at an alarming rate and show no signs of abatement. The number of accidents is too large to blame on a few idiotic pilots. They involve the average pilot.

There is a popular feeling in aviation that most fatal accidents are caused by deliberate recklessness. The pilot who kills himself by buzzing, low acrobatics, and exhibitionism is of little concern to the engineer. But the truth is that less than 35 per cent of the fatal accidents can be attibuted to extreme recklessness. This leaves the engineer with 65 per cent of the fatal accidents to eliminate. In 1947 this will amount to about 600 fatal accidents.

Most of these 600 accidents, in which approximately 1000 people will be killed, will be caused by human failure, such as flying into uncertain weather, failure to observe wires, operating the wrong lever or switch, and so on. Some of these accidents might be called the result of a reckless action, but they are probably no more so than common everyday actions such as burning toast, jaywalking, or overeating, that is, they are the results of normal human activity. There is very strong evidence that private pilots are normal human beings. Pilots are forgetful, absent-minded, awkward, nervous. They do not maintain top proficiency as pilots. They disregard elaborate instructions, and under conditions of stress, they should not be expected to function as well as test pilots, airline pilots, or well-trained military pilots. They do not always practice good airmanship.

The engineer should design for this type of normal person, not for the test pilot or airline pilot, but unfortunately, the engineering approach to this phase of safety suffers from the basic training of an engineer. The engineer has been molded into a relatively analytical careful person who takes great interest in studying highly technical literature and who applies himself with great diligence to an operating problem. His laboratory-work in college also militates against the broad approach to safety because he learns never to operate a switch or lever until he is "letter perfect" in its function. Moreover, he reads his instruments carefully all during the experiment, and he believes that all reasoning human beings would do likewise in an emergency.

An engineer may point to a manual which he had prepared for an airplane and say, "If the pilot had followed instruction 6 on page 30, the accident would not have occurred." The size of a manual is an index of the engineer's inability to avoid pitfalls and booby traps. It is a way for making up a deficiency in design just as the laws in the Bible and in criminal and civil codes are an index to our human weaknesses. The engineer is blinded by his own literacy. He should recognize that even a car operator seldom reads a manual all the way through, let alone consults it while operating the car. And when a man learns to fly, he should be regarded as being illiterate.

The designer should remember that the average person for whom he must design the airplane is careless, impatient, lacks the time to maintain pilot proficiency, and is not accustomed to exercising continual conscious judgment in the operation of mechanical contrivances. In brief, the private pilot should not be expected to exercise the airmanship required of military or airline pilots. Good airmanship requires blindfold familiarization with all instruments, constant alertness, sound judgment, and great skill in handling the aircraft at all times.

The goal of engineers and designers therefore should be the elimination of the airmanship which is now required to operate an airplane safely.

Powder-Metallurgy Patents

A COMPREHENSIVE list of powder-metallurgy patents has been compiled following an extensive study of patent literature in connection with an investigation in the field of powder metallurgy at the National Bureau of Standards. Representing more than a century of progress in this art, this information, which was obtained from a collection search of 2253 patents, and classified in related groups with a short abstract for each invention, has been made available to industry and others interested in this specialized field as N.B.S. publication M184, "United States Patents on Powder Metallurgy," by Raymond E. Jager and Rolla E. Pollard.

Published technical literature relating to this field is widely scattered, making it difficult for metallurgists to keep abreast of developments in this rapidly growing science. For this reason, the Bureau's listing and analysis of the patent literature classified as to production, handling and working, alloying, and application, should prove useful to those engaged in research and development in powder metallurgy. The publication is available from the Superintendent of Documents, Washington 25, D. C., at 30 cents per copy.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Civil Service Employment

To the Editor:

One encounters many broad statements on matters of general interest. For example, it is well known that all college professors are absent-minded, that all civil-service employees are incompetent, that all beautiful girls are morons, that all people with whom we disagree on matters of public interest are communists, and so on. The extent to which individuals accept such generalization is related to their initiative and discernment.

More specifically the various branches of the Federal Government are frequently placed at a disadvantage by college and university personnel who tend to accept the second of the foregoing generalizations without finding out whether or not it is true. It is the purpose of this letter to point out some of the reasons for and consequences of such acceptance.

In the first place, no person will deny that absent-minded professors exist. This is not a cause-and-effect relationship, but is merely due to the fact that in any group of this size, there is bound to be a certain proportion of the comic-strip type. Whether professors as a class are more absent-minded than the rest of the population has probably not been objectively investigated. The legend of the absent-minded professors probably results from the fact that thousands of students have been under their supervision, and, chafing at situations over which they have little control and being possessed of the exuberance of youth, they attempt to compensate their feeling of helplessness by the use of ridicule.

Professional men who work for the Government suffer from a similar situation. The average citizen does not concur in all the actions of his Government; therefore, he tries to find an object for his dislike, and generally settles for bureaucrats, incompetent clerks, or bumbling politicians. When ideas of this sort are expressed or published by sources from which one does not expect considered thinking, there is presumably little that one can do. However, when persons who are expected to be capable of better reasoning fall into the same error, it is well to set the record straight.

In any organization as large as the Federal Government, one encounters all sorts of individuals and all sorts of management practices, ranging from top flight to seriously substandard. This is no different from the aggregate of the colleges; some are brilliant leaders in education, others are diploma mills. Both extremes are a challenge to aggressive minds, the one to explore new frontiers, the other to do a job of diagnosis and cure. The colleges should realize, however, that they must analyze the federal employment situation completely and objectively, using facts rather than prejudice. The Federal Government is a going concern, it will continue to function, many of its research laboratories will offer some of the finest opportunities for professional development in the world, many of its departments will offer a chance to participate in business management on a scale impossible to attain elsewhere, other positions in the Government will offer only frustration and failure, just as they will in any other type of employment.

When a student is graduated from college, he is generally unfamiliar with the employment situation which confronts him. In turning for advice to the college faculty or to the placement director, he places upon these individuals a grave responsibility, not only for his own future welfare, but for the welfare of the various organizations which may hire him and his friends. This latter point is not always clearly understood, but it is abundantly clear that, if the colleges should take collective action, they could cause the gradual disintegration of any large industrial organization by advancing propaganda continually to students to the effect that employment with that organization was disadvantageous.

In offering advice to students and graduates, the colleges accept responsibility for its correctness and timeliness. More especially, since the world is presently in a state of unrest and the course which government activities must steer is critical, they must accept responsibility for directing into federal service an appropriate proportion of intelligent and energetic young men and women who can, as they mature, take on the job of guiding the policies of the United States.

When a young physicist comes to his faculty adviser for advice as to where to seek a career, should he be advised to go to the Bell Laboratories, to the Naval Research Laboratory, or to the University of Chicago? Should the young business graduate go to the Department of the Interior or to the Chase National Bank? The answer should be based on a factual understanding of the opportunities in each as they are related to the temperament and competence of the individual. The following list contains some of the factors which should influence a graduate in his choice of an organization:

1 Opportunity for self-improvement.
2 Quality of associates.
3 Opportunity for self-expression.
4 Recognition of merit by advancement.
5 Rate of pay including overtime.
6 Working conditions, hours, and facilities.
7 Reputation and ethics of employer.
8 Interference with private life.
9 Competition for jobs.
10 Freedom to publish one's own ideas and work.
11 Patent freedom.
12 Security and old-age benefits
13 Political interference.
14 Discrimination for race, religious, or political beliefs, etc.
15 Forced contributions.
16 Variety and scope of work.
17 Freedom to travel if necessary.
18 Attitude toward professional societies.
19 Amount of red tape in getting things done.
20 Freedom of transfer to more suitable work.
21 Vacations and sick pay.
22 Opportunity to use company's facilities for working out own ideas.
23 Financial stability of employer.

Faculty members and placement directors who have not informed themselves adequately on these points with respect to all types of employment are likely to mislead those who ask their assistance.

In many recent instances, the Government, more especially the Army and Navy, have contracted with colleges for research and development work. This affords an opportunity, which has not always been grasped, to observe the operation of a small segment of a federally supported project, unfortunately sometimes restricted by military-security requirements. In addition, it should be clear that by accepting such support, the colleges simultaneously accept an obligation to find out the facts about federal positions for their graduates, not to favor such positions, but neither to dismiss them lightly. It should never be forgotten that such contracts are to be administered by federal employees, the quality of whom therefore will be a major source of concern to the colleges themselves.

The writer is associated with the research and development program of the Navy, having come from the academic field just before the war. He elected to stay because of the high morale and high technical level of his associates and the importance of the work to national welfare and security. He would like to see all academic personnel become as well-informed on the subject of federal employment as himself and urges them to do so for the good of all concerned.

Royal Weller.[1]

---

[1] Naval Ordnance Laboratory, Washington, D. C.

Universal Military Training

To the Editor:

The leading editorial[2] in the July issue, on the report of the President's Advisory Commission on Universal Training omitted mention of the following most significant fact—one which the editor perhaps has overlooked, since it has not been publicized:

No one was appointed to the President's Commission who was not already an avowed advocate of universal compulsory military training. The commission's investigation, and the preparation of its report thus became a search for arguments supporting the preconceived views of the commission and of the President, and not an unbiased search for facts. Accordingly, the report is a solicitor's brief rather than the technical or scientific report which it purports to be. If this fact were generally known or honestly admitted, the report could be considered for what it really is—an argument for a basic change in the "American way of life" instead of masquerading as an impartial scientific study.

No true engineer or scientist would undertake to determine the relative merits of two opposed theories or two alternative types of equipment by assigning the investigation to a group composed solely of the advocates of one alternative. If called upon to evaluate any process or machine, the first thing which a true scientist or engineer would investigate is whether or not it had been used by others and, if it had, whether or not it had accomplished the results claimed for it.

Universal military training is not a new system. It has been in use in numerous countries for many years. How has it worked? Has it accomplished the results claimed for it?

(*a*) Did it prevent war? No! Every great European nation using it became involved in the war at the start.

(*b*) Did it discourage attack from without? No! Every great European nation using it was either attacked or itself did the attacking. England which did not use it did not hesitate to declare war on Germany which did.

(*c*) Did it protect any country? No! Every great European country using it was devastated, its cities destroyed, and its women and children mercilessly slaughtered.

(*d*) Did it protect democracy? No! Look at the great nations which used it—westward around the world we have Russia, Poland, Germany, Italy, France, Argentina, Brazil, and Japan. All but one of these were dictatorships. Of those not using it, the United States, England, Canada, and Australia, all were free from dictatorship. Clearly the system is the foundation upon which every dictatorship rests. It is the antithesis of democracy.

The editorial[2] mentions the so-called trial at Fort Knox. It should be noted that the boys there are "volunteers" and not "conscripts." The results being secured with the former could not be expected from the latter. While it is true that some of the abuses in conventional army camps have been eliminated, it must be remembered that "no amount of sugar-coating can make the pill less poisonous."

Let engineers and scientists be as critical of unproved assumptions, as diligent in collecting all pertinent facts, as objective and unemotional in their study and evaluation of the facts, and as careful to avoid drawing conclusions on the basis of incomplete data in this field as they are in their own.

Let us not use prewar Europe as a model for postwar America!

Frederick G. L. Boyer.[3]

---

[2] "Preparedness," Mechanical Engineering, vol. 69, July, 1947, pp. 539–540.

[3] Research Engineer, Patents, Hamilton, Ohio. Mem. A.S.M.E.

Mineral Fuel Reserves

Comment by R. J. Bender[4]

In the light of present available data, "proved" oil reserves is naturally the only basis that the author of this paper[5] could have used for his figures on petroleum; yet the term is misleading, because, while there is no expectation of further discoveries of solid-fuel reserves, exploration and discovery of petroleum is a never-ending process. True enough there may be periods during which new discoveries do not offset current consumption, but these periods are of comparatively short duration, and are brought about by spasmodic unfavorable conditions, such as low prices of crude oil, insufficient incentive for exploration, or an unusually perturbed economic situation. The "actual" reserves in crude oil of the United States and of the world are undoubtedly much greater than the proved reserves.

Nevertheless, the liquid-fuel reserves are small compared to the solid-fuel quantities, and the time will come soon, as the author states, when something practical will have to be done about a "conversion of raw material" for liquid-fuel products.

It would be appreciated if the author could supply information concerning the development in Europe and Asia of underground gasification of coal. To what extent and with what degree of success is this process being studied in this country, and what major products can be expected from its application?

Comment by H. J. Rose[6]

This excellent paper is an important reference for all who are interested in U. S. fuel reserves. Owing to present conditions, it will be timely to make further comparisons of these resources.

Laymen have sometimes suggested that oil or natural gas be used to replace the present uses of coal. Simple calculations, based upon the figures in Table 1 of the paper, bring out the following facts:

1 If the U. S. reserves of petroleum could be produced and used to supply the

---

[4] Assistant to the Chief Consulting Engineer, Sinclair Refining Company, New York, N. Y. Jun. A.S.M.E.

[5] "The National Fuel Reserves," by A. C. Fieldner, Mechanical Engineering, vol. 69, March, 1947, pp. 221–226, 228.

[6] Vice-President and Director of Research Bituminous Coal Research, Inc., Pittsburgh, Pa. Mem. A.S.M.E.

market for petroleum, and also to take over all uses of coal at the same Btu efficiency, then this country's proved petroleum reserves would last only $4^{1}/_{2}$ years.

2 If the U. S. reserves of natural gas could be produced and used to supply the market for natural gas, and to take over all uses of coal at the same Btu efficiency, then this country's proved natural-gas reserves would last only $6^{1}/_{4}$ years.

3 If the reserves of both petroleum and natural gas could be produced and used to supply their markets, and to take over all coal uses at the same efficiency, then the combined proved reserves of petroleum and natural gas would last only $8^{1}/_{7}$ years.

4 If the U. S. reserves of coal were used to supply the market for coal and to take over all petroleum and natural-gas uses at the same Btu efficiency, then this country's coal resources would last for 2085 years.

These striking comparisons help to explain the increasing rate at which coal research is being sponsored by both industry and Government.

Our coal reserves are so enormous that possible revisions in the estimated reserves are not of great interest at present. However, it is interesting to note that in England, estimates of remaining coal reserves have increased rather than decreased.[7]

The author makes a brief reference to the possible future use of atomic power. The figures cited from the Baruch report are based upon assumptions of 100 per cent load factor and 3 per cent interest on investment. With more realistic assumptions, the comparison would be still more favorable to coal since the investment cost of the atomic power plant is $2^{1}/_{2}$ times that for the coal-fired plant.

The demand for power has been increasing at a rather rapid rate for many decades. When atomic power becomes available, it may be expected to share in this increasing demand rather than to displace coal and other mineral fuels as energy sources.

Europe, with limited petroleum and natural-gas production, has developed huge and highly integrated industries built upon the processing of coal. Coal mining, power production, coke and steel production, long-distance manufactured-gas transmission, liquid-fuel production, and an enormous chemical industry have all been built around coal resources much smaller than those of the United States.

The author shows that 98.8 per cent of the mineral fuel reserves of this country are in the form of coal, while the proved reserves of petroleum and natural gas are only 0.2 per cent each. Conditions which have disturbed the coal industry recently should not lead anyone to minimize the present and future importance of coal, usually considered to be this nation's most valuable mineral resource.

AUTHOR'S CLOSURE

No completely satisfactory answer can be given to Mr. Bender's question on the present status of underground gasification of coal in Russia.

Although numerous papers have been published by the Russians describing and showing sketches of various methods that have been tried, the results given are qualitative rather than quantitative and leave much to be desired in forming a reliable opinion on the practical success of their efforts.

Preliminary experiments on underground gasification were started in Russia about 1931, and in 1933 five experimental projects were set up using different methods of preparing the coal bed, beds of different pitch and rank, and at different locations in the U.S.S.R. In 1938, the "Podzemgaz" trust decided to build a series of industrial scale stations in the Donetz coal basin (Gorlovka, Lisichansk, Schakhtinsk), the Lower Moscow coal basin (Podmoskovnaya, Krutov), and in the Kuznetzk basin of Siberia (Leninsk). The gas was to be used for power, chemical works, and domestic heating. The largest station, one of those in the Donetz basin, was planned to produce 14,000,000 cu ft of gas per hr, equivalent to about 500,000 tons of coal per year.

Little is known as to the stage of development and success of operation of these large stations. The Donetz basin plants probably were destroyed in the war, but some articles have been published recently indicating that work has been resumed in the Moscow coal-basin stations.

The best summaries of the Russian publications are cited[8] as a matter of record.

In September, 1946, the Bureau of Mines and the Alabama Power Company began planning a small-scale co-operative experiment on underground gasification of the Pratt bed near the Gorgas mine of the company in Walker County, Ala. The experiment was completed in April, 1947. No difficulty was experienced in maintaining combustion in the coal bed, nor did the roof-fall interfere materially with gasification. However, the average gas made was considerably lower in heating value than that of producer gas made in gas producers. This was due probably to insufficient blower pressure, leakage through the shallow overburden, and combustion to carbon dioxide.

It is believed that improvements can be made in the next experiment which will yield producer gas of satisfactory heating value for power production at the mine.

ARNO C. FIELDNER.[9]

Preserving the Cornish Engine

TO THE EDITOR:

I have read with much interest Mr. Kemp's communication in the May issue of MECHANICAL ENGINEERING, "Preserving the Cornish Engine." Mr. Kemp quotes the "duty" of some old Cornish engines, notably, "a second-hand engine from a mine in East Cornwall" as 97,146,268 ft-lb. The term "duty" is defined as the pounds of water raised one foot per bushel of coal.

On the basis of assumed weight of a bushel of coal of 84 pounds, with heat value of 14,000 Btu per pound, these figures imply a thermal efficiency of more than 10 per cent, including boiler and engine. These data are very interesting when compared with power plants installed in the last decade of the nineteenth century more than fifty years later, considering improvements in boiler construction, machining, higher steam pressures, and other improvements in design.

In this same connection the Boulton and Watt engine referred to, presumably built in the eighteenth century and working entirely at subatmospheric pressures, shows an over-all thermal efficiency of nearly 5 per cent.

SIDNEY WITHINGTON.[10]

Catalytic Cracking

COMMENT BY C. S. L. ROBINSON[11]

An underemphasized aspect of catalytic cracking[12] is the result upon the supply of cheap residual fuel oil. There are two general effects as follows:

---

[7] "Coal, Its Constitution and Uses," by W. A. Bone and G. W. Himus, Longmans, Green & Company, New York, N. Y., 1936, pp. 16–17.

[8] "The Underground Gasification of Coal," by L. J. Jolley and N. Booth, *Fuel in Science and Practice*, vol. 24, 1945, pp. 31–37, and 73–79.

"Underground Gasification of Coal—Some Considerations of Available Information," by E. T. Wilkins, *Fuel Economy Review*, vol. 23, 1944, pp. 14–18, and 58.

"Subterranean Gasification of Coal," by G. O. Nusinov, *Canadian Chemistry and Process Industries*, vol. 30, 1946, pp. 29–32.

[9] Chief, Fuels and Explosive Branch, Bureau of Mines, U. S. Department of the Interior, Washington, D. C.

[10] Chief Electrical Engineer, The New York, New Haven, and Hartford Railroad Company, New Haven, Conn. Mem. A.S.M.E.

[11] Engineer, Central Technical Department, Shipbuilding Division, Bethlehem Steel Company, Quincy, Mass. Mem. A.S.M.E.

[12] "Developments in the Petroleum Industry," by E. R. Smoley and T. T. Whipple, MECHANICAL ENGINEERING, vol. 69, April, 1947, pp. 293–299.

1 We have noticed that No. 5 fuel oil is a mixture of distillate oil and residual oil, while No. 6 has become generally unavailable in the East. These bunker fuels were always quite variable in composition but now more than ever they resemble coarse colloidal suspensions. The solid asphalt in the refinery residues does not dissolve when blended with distillate fuel oil.

2 The ratio of the price of the heavy fuel oils relative to that of the lighter fuel oils has increased. This is of great importance since the primary reason for burning the former is their lower price.

Power-plant engineers should be much concerned with the long-term outlook of relative fuel-oil prices and supplies. It changes the evaluation of fuel economy and the type of equipment to be installed. The developments described by the authors may discourage attempts to utilize residual fuels in Diesel engines and gas turbines. Some oil-fired steam plants, such as on new passenger ships, might find it advantageous to install only the simpler and lighter equipment for burning distillate fuels.

Thus the authors and the petroleum industry should be asked what are the revised quantities of refinery residuum that must be marketed as No. 5 or No. 6 fuel?

AUTHOR'S CLOSURE

The question "What are the revised quantities of refinery residuum that must be marketed as No. 5 or No. 6 fuel?" is influenced by supply and demand. It is expected that residuum fuel production will continue to decrease in the East, Gulf Coast, and central part of the United States and that prices for intermediate products such as distillate fuels and residuum fuels will advance in price in accordance with supply and demand.

American Petroleum Institute "Statistical Bulletin," Volume 28, No. 36, July 10, 1947, Form No. 10, shows production of (*A*) gas oil and distillate fuel, (*B*) residual fuel, and (*C*) total of (*A*) and (*B*) from 1918 to date. These figures show an increase in residual fuel-oil production from 1932 to 1945 of from roughly 600,000 barrels per day to 1,300,000 barrels per day, while the per cent of crude remained between 25 and 29. During the same period, gas oil and distillate fuel increased from about 200,000 barrels per day to 700,000 barrels per day. The per cent of distillate fuels on crude, however, increased from about 9 to 15. In 1946 there was a decrease of 100,000 barrels of residual fuel-oil production and an increase of 100,000 barrels of distillate fuel oil. Any attempt at predicting production figures in the future must take into consideration the increasing demand for all petroleum products, the lower-grade crude which will be run to meet these demands, and the application of the law of supply and demand as to quantities of residual fuel oil which will be made. These quantities are dependent also on types of crude run, quantity of cracking carried out, type of cracking used (whether catalytic or thermal), and the amount of coking, which are again dependent on supply and demand.

To summarize, there is unquestionably a trend in the Gulf Coast and central and eastern U. S. refineries away from the production of residual fuel oils so that in these areas it is expected that the price of heavy fuel oils will stay high as these heavy fuel oils can be obtained in accordance with supply and demand at prices commensurate with distillate fuel oils and the yields that may be obtained from crude. In South America, the Pacific Coast, and the near East, however, refineries will probably produce larger quantities of residual fuel oils.

E .R. SMOLEY.[13]
T. T. WHIPPLE.[14]

---

[13] The Lummus Company, New York, N. Y.

[14] The Lummus Company, New York, N. Y. Mem. A.S.M.E.

A.S.M.E BOILER CODE

Proposed Revisions and Addenda to Boiler Construction Code

IT IS the policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revisions of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published herewith with corresponding paragraph numbers to identify their location in the various sections of the code and are submitted for criticism and approval from anyone interested therein.

It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-3. Revise to read:

P-3 Open hearth or electric-furnace steel pipe or steel tubing [in accordance with one of the following specifications] may be used for a boiler drum or other pressure part exposed to the fire or products of combustion provided: [the nominal diameter of the pipe or tubing is not greater than 18 in.]

(**1**) SPECIFICATIONS SA-106 OR SA-206 MAY BE USED UP TO DIAMETERS NO GREATER THAN 24 IN., AND

(**2**) IF THE NOMINAL DIAMETER OF THE PIPE OR TUBING IS NOT GREATER THAN 18 IN., THE FOLLOWING SPECIFICATIONS MAY BE USED: (The specifications now listed in Par. P-3 will be given with the exception of SA-106 and SA-206).

PAR. P-112(**c**). Add the following:

The hydrostatic test pressure shall be as specified in Par. P-329.

PAR. P-186(**e**). Add the following:

Nonpressure parts used only for extending (increasing) the heat-absorbing surface may be attached to carbon steel tubes complying with Specifications SA-183, SA-192, and SA-210 by fusion welding, either continuous or intermittent, without stress-relief.

PAR. P-294. Add the following:

The gage cock connections shall be not less than $^1/_2$ in. pipe size.

Par. U-208(**c**). Add the following as the third section:

If sections are flamecut from the vessel wall, the opening in the vessel wall shall not exceed $1^1/_2$ in. on any diameter, or the width of the

Tables P-7 and U-2. Add the following:

Specification SA-27 Grade	—20 to 650	700	750	800	850	900	950	1000
60-30	12000	11400	10400	8300	6350	4400	2600	1350
65-35	13000	12300	11100	8600	6400	4400	2600	1350
70-36	14000	13300	11900	8950	6450	4400	2600	1350
Specification SA-30 Grade A, firebox	11000	10400	9500	8000	6300	4400	2600	1350

weld, whichever is greater, as measured after removal of all loose scale and slag accumulation. Flamecut specimens shall be sawed across the weld to obtain a plane surface which will expose the full width of the weld on the cut surface.

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with Committee Secretary, A.S.M.E., 29 W. 39th St., New York 18, N. Y.

The procedure of the Committee in handling the Cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval and then issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of its Executive Committee of July 29, 1947, and approved by the Council on September 3, 1947.

CASE No. 1051

There is a typographical error in the reply to this case as it appears in September, 1947, MECHANICAL ENGINEERING. The sentence should read as follows: "The welding shall conform to Par. P-186 and Fig. P-36."

CASE No. 1052 (*Special Ruling*)

Inquiry: The A.S.T.M. has approved a 1947 "Tentative Specifications for Steel Plates for Pressure Vessels for Service at Low Temperatures" (A 300-47T). This specification provides for sampling and evaluation of impact test results that differ from the requirements of Par. U-142. May steel plates purchased to the impact testing requirements of this specification be used as complying with the intent of Par. U-142?

Reply: It is the opinion of the Committee that experience with the fabrication and use of unfired pressure vessels for low temperature justifies two changes in the requirements for impact testing that will bring them into conformity with A.S.T.M. Specification A 300-47T. The requirements of Par. U-142 shall be met in all other respects except that:

(1) Each plate as rolled may be qualified by one set of impact tests taken from the plate (See Par. U-142(**b**)(1).

NOTE: The term "plate as rolled" used here refers to the unit plate from a slab or rolled directly from an ingot in its relation to the location and number of specimens; not to its condition. If the plate is sheared or otherwise cut into smaller sizes after rolling, the impact test made from the original plate shall govern.

(2) The requirements for each set of impact tests shall be as follows in lieu of those stated in Par. U-142(**g**):

(*a*) Each impact test value shall constitute the average value of the three specimens of each set. This average value shall be not less than the minimum requirement. One value may be below but not less than two thirds of the minimum requirement;

(*b*) If the value for more than one specimen is below the minimum requirement, or if the value for one specimen of a set, but not the average of the set, is below two thirds of the minimum requirement, a retest of an additional set of three specimens may be made, each of which specimens must meet the specified minimum value.

CASE No. 1054

(*In the hands of the Committee*)

CASE No. 1055 (*Special Ruling*)

Inquiry: Will material manufactured to the requirements of Specification SA-182, but having a chemistry complying with Specification SA-213, Grade T21, except with a maximum phosphorus and sulphur content of 0.04 per cent, meet the intent of the Code?

Reply: It is the opinion of the Committee that the above material when made by the open-hearth process will be considered as meeting the intent of the Code.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Engineering Organization and Methods

ENGINEERING ORGANIZATION AND METHODS. By James E. Thompson. McGraw-Hill Book Co., Inc., New York, N. Y., 1947. Cloth, 6 × 9 in., 332 pp., illus., charts, index, $4.

REVIEWED BY WILLIAM R. MULLEE[1]

THIS book is one of the McGraw-Hill Industrial Organization and Management series. It contains a wealth of detailed information covering practices and procedures in engineering departments of manufacturing plants. Most of the case examples are from the aircraft industry but they can readily be applied to other industries both large and small.

Although the title may lead one to believe that the book is primarily concerned with organization problems, the approach is essentially that of showing how to set up and carry on the everyday work of an engineering department in an effective manner. Numerous drawings, copies of forms and records, along with line diagrams are illustrated, many of which can be put right to work in the plant of the engineer-reader to improve engineering practices.

The organization of an engineering department is covered by one chapter on organization and another on fundamentals of engineering management. Seven chapters are devoted to the drafting room covering standards, systems, and methods of preparing and releasing engineering information. The remaining six chapters are devoted to: operation, personnel, cost control, planning, technical, and general services respectively.

Under organization the author lists the duties of engineering personnel and a number of interesting organization charts are drawn up for various types of setups. While most of these charts are for large organizations the same principles can be applied to smaller units.

The chapter devoted to operation, shows the various ways an engineering department can function and the liaison with inspection, purchasing, sales, and other departments. That devoted to personnel covers the setups usually found in a large engineering department but the job-performance rating forms and other measurement techniques can be applied to clerical and supervisory personnel in smaller plants.

---

[1] Professor, Administrative Engineering, New York University, New York, N. Y. Mem. A.S.M.E., Chairman, Administrative Organization Committee.

Cost control is covered by case examples of estimating product cost, methods improvements, and budgetary control methods. Likewise planning the work load in the engineering department is liberally illustrated with planning charts, cumulative time curves, and line diagrams to show the progress made against predetermined load schedules. Simple methods of estimating work loads are discussed.

About half of the book relates to drafting-room practices including the preparation, release, and changing of drawings and engineering instructions. Probably the greatest value of the book lies in this section. Beginning with a chapter on standards, covering the preparations of standard practice manuals, standard symbols, drawing sizes, nomenclature, and product design, this section continues with additional chapters on drawing and report numbers, forms and title blocks, drawing release, print control, release of engineering information, and drawing changes. These chapters cover drafting-room practice in minute detail with dozens of examples of part drawings, typical production forms, record systems, and control procedures taken from actual practice in aircraft plants. Here, due to thousands of component parts and the need for careful integration of all of the parts, a very intricate and foolproof system is required. These chapters contain many ideas that can be put to work in less elaborate form in the average engineering or drafting department.

A small section of the book covers the various technical and general services furnished by an engineering department, including preparation of material, process and method specificatons, handbooks, customer service, library and clerical functions. An appendix provides case examples of a typical engineering cost procedure and also cost analysis investigations.

All the routines necessary for the orderly preparation, processing, recording, and release of engineering information are outlined in complete detail.

This book should prove useful to engineers and plant managers who wish to improve the functioning of their engineering organization, and to modernize their drafting-room procedures.

Fundamentals of Naval Warfare

FUNDAMENTALS OF NAVAL WARFARE. By Comdr. Lee J. Levert, U.S.N.R. (Inactive). The Macmillan Company, New York, N. Y., 1947. Cloth, $5^5/_8 \times 8^3/_8$ in., 488 pp., illus., $5.

REVIEWED BY HAROLD G. BOWEN[2]

THE author states in the preface that his "book is intended for the general public and seeks to outline the principles and methods of naval warfare" in order that "dissemination of such knowledge should contribute to a more enlightened support of measures designed to improve the security of the Nation."

The author has succeeded in his mission to a remarkable degree and the public has urgent need for more studies in this category.

The Navy is and has been for a long time a completely mechanized service. It is highly technical in all its branches and is the largest engineering activity in the world. Parenthetically, let us hope, due consideration will be given to this fact during the impending merger.

Because naval warfare covers practically the whole technological spectrum, let alone many other features fundamental to all warfare, this book of necessity has an extremely wide coverage and this wide coverage is precisely what constitutes its chief value.

Obviously a reviewer in such a case is compelled to confine himself almost wholly to generalities and as a rule to his own specialty. It would require a staff of experts to do this book real justice and a review as long as the book itself.

The author believes that weapons are the "kernel of the entire situation." I doubt that. I think that continuous and intelligent observation of the trends and developments in technology and their prompt incorporation into Naval Warfare is the key to Naval or all other warfare.

Again, "Every warship designer is confronted with a situation created by the strategical and tactical picture then in existence. He is told by naval authority what kind of ship would be strategically and tactically suitable for successful prosecution of a given mission. The designer is told what is suitable, and it rests with him to determine whether it is possible to attain all the desired features or, if it cannot be done, to arrive at a compromise which is both feasible and acceptable."

Let us comment on these two ideas of the author.

The author has described the practice in vogue in the routine design of naval vessels. The new and radical ideas which from time to time enormously increase the military value, or ***military characteristics*** of naval vessels, to use the accepted term, come from the bottom up. They are proposed by engineers and not by "naval authority." Too often they are sold to the military only after great opposition. As the author himself says, "Conservatism, inherent in all human beings, resists change so long as the old methods succeed." In these days of astronomical outlays for the Armed Service much more attention must be paid to outmoding the equipment of possible enemies and less reliance on overwhelming him.

It is up to the material people, engineers, to force the adoption of the most advanced developments irrespective of their origin, into new design whether intended for surface, subsurface, or air use.

The great advances in engineering in recent years have kept down machinery weights in spite of the enormous increase in horsepower, and made possible the allocation of that much more weight to armor and armament. It is true that a ship exists for her weapons, but it is also true that these weapons are but part of a team and machinery (engineering) is a most important part of that team.

High-pressure, high-temperature, high-speed turbines, double-reduction gears, air-encased boilers, flame-proof cable, alternating-current electricity have all so improved the economy (cruising radius) and reliability of our ships, have so freed weight for employment in more armor and armament that they have actually raised the military characteristics of ships.

The development of electric drive and multicylindered diesels in submarines made possible the splendid record of our submarines in the Pacific.

All these developments did but follow the trends of the most advanced engineering which could be found in the United States. "Naval authority" as I understand that term did not dictate these developments. It did take tactical and strategical advantages of these developments after they had been procured and proved by engineers.

No book of this nature is complete without adequate reference to industry. Great tribute has been paid and will always be paid to the work of management and labor in turning out such unbelievable amounts of ships, aircraft, guns, tanks, and equipment as to literally overwhelm our enemies. Several factors are responsible for our winning the war and not the least of these was American industry.

---

[2] Vice-Admiral, U.S.N. (Retired), Washington, D. C. Hon. Mem. A.S.M.E.

Nowhere near enough has been said about the designer, both in industry and in the Navy, who produced designs in general superior to those of any other nation.

When our ships joined the British Fleet in North Atlantic waters, the British were amazed that our ships could keep the sea so long without refueling and without repairs.

While it is true that naval designers were constantly raising the sights on performance and have been doing so for years, it is also true that the accomplishments would not have been possible without the aid of American industry, the most progressive industry in the world.

The author is not aware, and understandingly so, that by 1940, the Navy had proved afloat, in a destroyer for main propulsion, steam at 1300 psi and 925 F. The war delayed taking advantage of this advance until recently.

The author calls attention to the dramatic and effective contribution of radar and the R.A.F. in the defense of Britain. It is not so well known that we had radar on our ships before and during Pearl Harbor and that our own native radar was usefully employed during the earliest days.

We led the world in adopting radar to surface and subsurface vessels just as the R.A.F. led the world for a time in airborne radar. The answer? Radar was developed in England by the R.A.F.; in the United States, by the Navy.

The author states "means of detection were also limited until World War II, to visual observation for surface targets and underwater detection devices which were introduced during World War I."

Lest there be misunderstanding, may I say that the underwater detection devices of World War I, which were sonic, were completely discarded after that War. By the time of World War II, supersonic devices had been completely developed and installed on all submarines.

I am surprised to find insufficient reference to the Seabees. The Seabees were certainly among the extraordinary developments of the late War.

The author's attempt to evaluate present and proposed types of naval vessels is a decided step in the right direction. Displacement is a function of progress. A ship always increases her displacement with age on account of the continual addition of new equipment introduced to bring her more nearly in line with the advance in the military characteristics of new ships. Certain types of vessels should have a factor of safety built into their design metacentric height to meet just this contingency. It is time to forget the names of the various types of naval vessels and to develop new types, based on purpose, but also on due consideration of military characteristics versus displacement. For instance, it was obvious during the rebuilding of the Navy in the late 30's that 10,000 tons displacement is a barren spot on any curve of tonnage versus military characteristics. All nations lagged apparently in realizing the increase necessary to displacement to accommodate the products of progress.

They similarly lagged in providing adequate anti-aircraft protection for battleships and large surface vessels.

Leadership is such an indispensable factor in winning wars that comment on this subject is scarcely necessary. If you do not have it, it is just too bad. Bold leadership somewhere could have averted Pearl Harbor. But even the best leaders require the tools to work with and the author is correct in emphasizing the greatly accelerated tempo of research and development in this day and age. Trends in these lines must be carefully observed and promptly taken advantage of, in order that we may at the beginning of war be so far ahead in material that we actually start in the position of the greatest technological superiority possible. With such an attitude we must combine the will and ability and open-mindedness to be the first to realize the significance of the impact of the airplane, rocket, guided missiles, and atomic energy on the conduct of war as we know it today, and above all, not play any favorites. Things may or may not happen to change his mind on his prophesied demise of the aircraft carrier.

The book reflects these attitudes and this review is intended to support the author in his attempt to inform the public of the United States in the complex fundamentals of naval warfare. It is stimulating and provocative. I recommend it as a must.

Reclaimed Rubber

Reclaimed Rubber. The Story of An American Raw Material. By J. M. Ball. Rubber Reclaimers Association, Inc., New York, N. Y. 1947. Cloth, 6 × 9 in., 248 pp., 78 Figs., $5.

Reviewed by Penrose R. Hoopes[3]

RECLAIMED rubber has been an industrial raw material for one hundred years. Charles Goodyear made one of the first attempts to reclaim vulcanized rubber and, as the use of manufactured rubber goods increased, numerous engineers, chemists, and manufacturers devoted themselves to the problems of reversing the process of vulcanization in order to produce a plastic raw material suitable for remanufacturing. The result of these efforts was the reclaimed rubber industry, an industry which today plays an important part in the technology and economics of rubber-goods manufacturing.

Strictly speaking, reclaimed rubber is not devulcanized rubber. The sulphur and compounding ingredients remain in the reclaimed stock. The material has, however, distinct properties of its own quite different from those of crude rubber, which make it a useful ingredient in many types of mechanical rubber goods. Variations in the methods by which scrap rubber is reclaimed result in widely different characteristics of the finished product. Reclaimers have developed these methods to produce a series of standardized materials which fill a major place in rubber compounding.

Mr. Ball's book is an admirable history of this development. Starting with the early experiments in grinding and reprocessing rubber scrap, the evolution of the acid and alkali processes is described and illustrated with a fine series of photographs and flow charts. The contributions of the men who pioneered the various developments, the corporate changes which have taken place in the industry, and the fluctuations in markets and sources of raw materials are discussed. A chapter on the use of reclaimed rubber during the recent war, after the supply of crude was cut off and before the synthetic plants were in production, is a tribute to the resourcefulness of American manufacturers.

The book is based upon extensive research in which the author had access to substantially all of the existing records of the makers and users of reclaimed rubber. His background is that of a rubber technologist and his treatment of the subject is notable for objectivity, clarity, and skillful handling of the materials. It is no exaggeration to say that this is one of the most competent historical studies of an American industry which has yet been published.

---

[3] Consulting Mechanical Engineer, Philadelphia, Pa. Mem. A.S.M.E.

Books Received in Library

Air Conditioning and Elements of Refrigeration. By S. P. Brown. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1947. Cloth, 6 × $9^1/_4$ in., 644 pp., illus., diagrams, charts, tables, $6. This book shows how to calculate heating and cooling loads, and how to heat, cool, ventilate, and otherwise condition air in any building. Selection of equipment, automatic controls, and the design of air ducts and liquid piping systems are fully covered. Refrigeration theory, application, and equipment selection are also included. The book contains all the tables necessary for elementary design work. It is intended as a reference work for those actively engaged in the field as well as a guide to beginners.

Aircraft Materials and Processes. (Pitman Aeronautical Engineering Series.) By G. F. Titterton. Third edition. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1947. Cloth, 6 × $9^1/_4$ in., 357 pp., illus., diagrams, charts, tables, $4.75. Essential information on materials and processes used in the construction of aircraft is described from a utilitarian point of view. The data are from government sources and the Handbook of the Society of Automotive Engineers. Definitions of physical terms, heat-treatment terms, and physical-test terms are given. Steel and its alloys, including corrosion-resisting steels, nickel alloys, copper and its alloys, wrought aluminum alloys, magnesium alloys, wood and glue, fabrics and dope, plastics, transparent materials, rubber and synthetic rubbers are materials with which the book deals. The following processes are also described: testing materials, heat-treatment of steel, surface hardening, shaping of metal, aluminum alloy casting, metal-joining processes and corrosion and its prevention. The selection of material for all parts of aircraft is also treated.

Refractories in Turbine Blades plus Miscellaneous Applications, Pb Report 4260. By S. S. Kistler. Office of Technical Services, Department of Commerce, Washington, D. C.; Hobart Publishing Co., Washington, D. C., January, 1947. Paper, manifold, 8 × $10^1/_2$ in., 31 pp., illus., tables, $2. This report is concerned with the efforts made by the Germans to produce ceramic substances suitable for combustion turbine blades. The various developments of several important companies are described, with discussion of the physical properties and effectiveness of application.

Rockets and Space Travel, the Future of Flight Beyond the Stratosphere. By W. Ley. Viking Press, New York, N. Y., 1947. Cloth, $5^1/_2$ × $8^1/_2$ in., 374 pp., illus., diagrams, charts, tables, $3.75. Beginning with the early concepts of space travel and conditions beyond the limits of the earth's atmosphere, the author proceeds to a discussion of the actual and practical development of the rocket as a means of motive power. The new edition presents an extensive account of the German experiments which lead to the V-2 weapon. Considerable space is devoted to the technical and physiological problems connected with the take-off and controls for space flight. A technical-data section and a bibliography are appended.

S.A.E. Handbook 1947 Edition. Society of Automotive Engineers, New York, N. Y., Fabrikoid, $5^1/_2$ × $8^1/_4$ in., 822 pp., illus., diagrams, charts, tables. $5 to members, $10 to nonmembers. This standard reference work contains all current S.A.E. Standards and Recommended Practices of the Society, except those specifically for aeronautical use which are, however, listed and identified. Among the new standards in this edition are those for hydraulic brake fluids, involute serrations, automotive steel castings, low-alloy, high-tensile steel specifications, and mountings for license plates. Current new data on crankcase-oil types, copper and silver brazing alloys, and arc-welding electrodes are published as general information.

Science Since 1500. By H. T. Pledge. Philosophical Library, New York, N. Y., 1947. Cloth, 6 × $9^3/_4$ in., 357 pp., illus., diagrams, charts, maps, tables, $5. Following an introductory discussion of scientific development prior to 1500, the succeeding centuries are considered successively, giving a cross section of the parallel evolution of the several sciences. Together with the progressive discoveries and inventions and the epoch-making theories, some account is given of the men who contributed. This condensed recapitulation of the labors and achievements of science since the Renaissance is illustrated by charts, graphs, and maps demonstrating the continuity of the process. There are detailed subject and name indexes and a suggestive bibliographical note.

Shot Peening, published by American Wheelabrator & Equipment Corp. (formerly American Foundry Equipment Co.), Mishawaka, Indiana. Paper, 6 × 9 in., 1946, second edition, illus., diagrams, charts, tables, $1.50. The first part of this book is devoted to a discussion of the applications and advantages of shot peening and the equipment and procedures involved. The second part covers the theory of prestressed surfaces in relation to shot peening. Brief reference lists accompany the chapters of Part 1, while Part 2 contains a fairly extensive bibliography. It is well ilustrated.

Six-Place Tables, with Explanatory Notes. By E. S. Allen. Seventh edition. McGraw-Hill Book Company, Inc. New York, N. Y., and London, England, 1947. Cloth, $4^1/_4$ × $7^1/_4$ in., 232 pp., tables, $2.50. This standard reference book presents a selection of tables of squares, cubes, square and cube roots, fifth roots and powers, circumferences and areas of circles, common logarithms of numbers and of the trigonometric functions, natural trigonometric functions, natural logarithms, exponential and hyperbolic functions, and integrals. An introductory section explains briefly the theory of logarithms and the use of logarithmic and certain other tables.

Strange Story of the Quantum. By B. Hoffmann. Harper & Brothers, New York, N. Y., and London, England, 1947. Cloth, $5^1/_4$ × $8^1/_4$ in., 239 pp., diagrams, tables, $3. In narrative style the author starts with Planck's postulation of energy quanta in 1900, and carries the reader through the turbulent speculations on the basic qualities of matter and radiation, of space and time, which filled the succeeding forty-odd years. In clear, careful, nontechnical language, and by the use of simple analogies, he renders intelligible to the layman the obscure or complex concepts by which physicists have sought to distinguish or reconcile the wave and the particle. The relations to nuclear physics and a foreshadowing of the future appear in an epilogue.

Library Services

Engineering Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

Time and Thermodynamics. By A. R. Ubbelohde. Oxford University Press, New York, N. Y., 1947. Cloth, 5 × $7^1/_2$ in., $2.25. This book deals with the significance of thermodynamics for certain problems of human observation and experience. So far as possible, nontechnical terms are used in describing the historical development of the concept of entropy for measuring the trend of events in time. Simple illustrations of important statistical equilibria are also given in order to reach a more fundamental understanding of the nature of time.

Visible Speech. By R. K. Potter, G. A. Kopp, and H. C. Green. D. Van Nostrand Co., Inc., New York, N. Y., 1947. Cloth, $7^1/_2$ × 11 in., 441 pp., illus., diagrams, charts, $4.75. Part 1 of this volume describes the electronic principles employed and the instruments which have been devised for the production of visible speech. Part 2 presents a step-by-step course of instruction in how to read visible speech. Part 3, after considering the interests of the deaf, proceeds to other practical applications of the principles of visible speech in phonetics, music, language study, and physiological diagnosis. More than 500 reproductions of spectrograms show all the sounds and important sound combinations in American speech, with many examples of words, phrases, and sentences.

Work Measurement Manual. By R. M. Barnes. Third edition. Wm. C. Brown Company, Dubuque, Iowa, 1947. Paper, $8^1/_2$ × 11 in., 218 pp., illus., diagrams, charts, tables, $3.75. This manual describes in detail how an organization may proceed to check the ability of its time-study men to set standards and to improve their accuracy and consistency. It also explains how these standards may be compared with national standards being developed by the author. Some general information on time-study work precedes the main section, and subsequent sections contain suggestions for community time-study surveys and for the development and use of standard data. The book also contains the results of an industrial-engineering survey of eighty companies, including time-study and related clauses from union contracts.

Writing Scientific Papers and Reports. By W. P. Jones. Wm. C. Brown Company, Dubuque, Iowa, 1946. Paper, spiral binding, $8^1/_4$ × 11 in., 115 pp., diagrams, $2.50. The general intent of this text is to present students with a number of simple problems in scientific exposition, and to give them instruction and practice in organizing ideas and in communicating these ideas to the reader. Necessary information concerning writing style, sentence structure, punctuation, capitalization, and abbreviations, is included.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

Compiled and Edited by A. F. Bochenek

MIDWINTER SCENE OF THE BOARDWALK IN ATLANTIC CITY, N. J.

(Because of tempering Atlantic sea breezes winters are delightful and snows rare. Shops and hotels remain open to accommodate thousands of winter visitors.)

Educational Exhibits and Resort Atmosphere to Add New Notes to A.S.M.E. 1947 Annual Meeting

IN choosing the Chalfonte-Haddon Hall Hotels, Atlantic City, N. J., as headquarters of its 1947 Annual Meeting, Dec. 1–5, 1947, The American Society of Mechanical Engineers decided to hold its principal meeting of the year away from New York, N. Y., the city in which the Society was founded 67 years ago.

Several factors influenced the choice of Atlantic City. Vexed by the confusion and pressure that characterized commercial hotels during the war years, the A.S.M.E. Meetings Committee was determined to find for the 1947 Annual Meeting a quiet setting in which the business of the Society could be conducted with the sociability and good-fellowship which have long been the hallmark of A.S.M.E. meetings. So great has been the demand on hotel facilities in recent years, that New York hotels have found it difficult to meet the needs of the Society. The warm invitation extended by Atlantic City and the offer of unsurpassed convention facilities and free use of public rooms made a favorable impression on Committee members. A factor in the decision was the large number of members who voted last December in favor of an Atlantic City meeting.

Popular Winter Rest Center

It is not generally known that Atlantic City is a popular winter rest center. Situated on an island almost five miles out to sea, the city benefits from the tempering sea breezes of the Atlantic which make the winters unusually mild and snows rare. Devotees of the winter rest habit come annually to enjoy the uncrowded recreation facilities along the boardwalk. They rest in deck chairs in the bright winter sunshine, ride horseback along the sands, golf, and shop in the delightful setting of magnificient hotels on the edge of the sea.

In keeping with this leisurely atmosphere, the Meetings Committee has worked up a moderately different program to take advantage of the recreational facilities. In contrast to the New York meetings, evenings will be free of technical sessions with the exception of Thursday evening. A Free cocktail party is planned for members on Monday evening. On Wednesday evening before the banquet a "pay as you go" cocktail bar will be available to add color to the banquet. Five luncheons, three dinners, and the banquet will make up the formal social program of the meeting.

Educational Exhibits Planned

A new note at the 1947 Annual Meeting will be an educational exhibit of equipment and materials reflecting recent engineering and scientific developments in the field of jet propulsion, gas turbines, and nuclear energy. Noncommercial in scope and loaned by the Armed Forces and industrial organizations, the exhibits will be scattered throughout the lounge floor, parlor, gallery, and solarium of the headquarters hotels.

Of particular interest to engineers will be a series of exhibits created by James D. Mooney, member A.S.M.E., president of the Willys-Overland Motors, Inc., to demonstrate the operation of the laws of economics. Called upon to write an article on foreign exchange, Mr. Mooney decided that many of the abstract concepts of economics could be more easily understood if demonstrated graphically by making use of an engineering technique. With the aid of Walter Fried, consulting engineer of New York, N. Y., he constructed several exhibits using the engineering principles of flow and buoyancy in combination with graphs and charts to show how economic variables affect such economic concepts as supply and demand, commodity prices, value of money, and distribution of income. Visitors will be able to manipulate economic factors represented in the exhibits and observe how each such disturbance creates a different equilibrium of economic values.

Make Reservations Early

While reservations should not be a problem in Atlantic City, members are urged to make them early. For accommodations at the Chalfonte-Haddon Hall Hotels, members should write to Philip E. Paylett, Chalfonte-Haddon Hall Hotels, Atlantic City, N. J. Copies of correspondence should be sent to Society Headquarters in New York.

Outline of Technical Sessions

At the time of going to press professional divisions and technical committees of the Society announced intentions to sponsor a total of 74 sessions. The final program is not yet complete but the following outline will give the pattern of the meeting:

Applied Mechanics Division: Sponsoring five sessions and co-operating in one.

Aviation Division: Sponsoring one session and co-operating in four.

Heat Transfer Division: Sponsoring five sessions and co-operating in one.

American Rocket Society: Sponsoring two sessions and co-operating in two.

Industrial Instruments and Regulators Division: Sponsoring two sessions.

Research Committee on the Property of Gases: Sponsoring two sessions.

Education Committee: Two sessions.

Hydraulic Division: Three sessions.

Metals Engineering Division: Sponsoring four sessions.

Railroad Division: Sponsoring four sessions and co-operating in one.

Oil and Gas Power Division: Sponsoring two sessions and co-operating in four.

Power Division: Sponsoring four sessions.

Production Engineering Division: Sponsoring three sessions and co-operating in one.

Materials Handling Division: Sponsoring two sessions and co-operating in two.

Nuclear Energy Application Committee: Sponsoring one session.

Fuels Division: Sponsoring four sessions and co-operating in one.

Gas Turbine Power Division: Sponsoring two sessions and co-operating in five.

Machine Design Division: Three sessions.

Management Division: Sponsoring four sessions and co-operating in one.

Process Industries Division: One session.

Safety Committee: Sponsoring one session.

Power Test Codes Committee: One session.

Research Committee on Fluid Meters: Sponsoring one session.

Rubber and Plastics Division: Sponsoring two sessions.

Research Committee on Lubrication: Sponsoring two sessions.

Citizenship Committee: One session.

Wood Industries Division: Two sessions.

Research Committee on the Effect of Temperature on the Properties of Metals: Sponsoring one session.

Information on authors and papers to be presented by the various divisions and committees will be published in the November issue.

Note to Junior Members

With this issue the Junior Committee inaugurates its *Junior Forum*. See pages 877 and 878. This space is reserved for discussion of your problems. There you will read what other A.S.M.E. junior members are thinking and doing.

The *Junior Forum* should reflect your ideas. If it does not, write to the editors. Your ideas and opinions will be published. In the *Junior Forum* these ideas will enjoy national circulation.

Address correspondence to C. H. Carman, Jr., Chairman, *Junior Forum* Editoral' Committee, A.S.M.E., 29 West 39th St., New York 18, N. Y.

Graphic Arts Exhibit Planned for Annual Meeting

THE Photographic Group of the Metropolitan Section of The American Society of Mechanical Engineers is sponsoring a graphic arts exhibit at the 1947 Annual Meeting.

All members and nonmembers are cordially invited to submit exhibits.

All photographic prints must be mounted on 16 × 20 in. cardboard mounts. There is no time limit in which the pictures should be taken. There will be five subdivisions consisting of portraits, landscapes and seascapes, pictorial or still-life, genre, and mechanical or industrial pictures. A contestant may submit a total of ten prints, but not more than five from one group. Three prizes will be awarded in each group. These rules should permit you photographers to submit a wide variety of work and should insure a well-rounded photographic exhibit.

Other exhibits of graphic arts will be accepted but not more than five examples from any one group will be accepted.

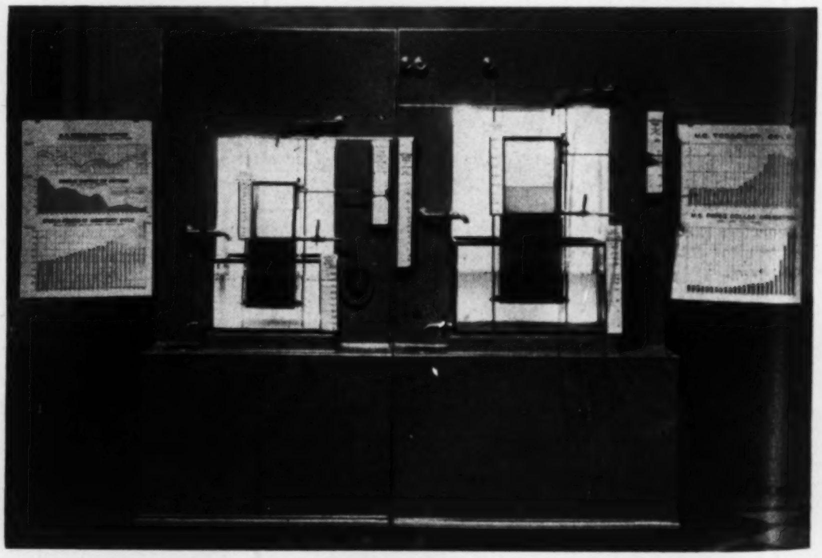
Directions for mailing your pictures or exhibit will be sent to each contestant at a later date. Applications for the exhibit can be obtained by mailing your request to Edward S. Rowell, The Babcock & Wilcox Company, 85 Liberty Street, New York 6, N. Y.

"Briefing the Record" Goes to Occupied Countries

OF the 145 magazines chosen by the War Department's Civil Affairs Division from which to select material to present the peoples of the occupied areas with a comprehensive picture of life and thought in America, MECHANICAL ENGINEERING is the only one representing the American engineering societies.

According to a recent War Department release listing the selections made during the twelve months ending June 30, 1947, 22 selections were made from "Briefing the Record" section of MECHANICAL ENGINEERING. Only two other magazines were more popular: *Farmer's Digest* with 25 selections and *Science News Letter* with 24 selections.

In all, more than 2000 pieces of contemporary American writing were selected, edited, and shipped by the Civil Affairs Division of the War Department to Germany, Austria, and Trieste for publication in the United States licensed press in those countries.



ONE OF THE J. D. MOONEY EXHIBITS TO BE SHOWN AT THE 1947 ANNUAL MEETING IN ATLANTIC CITY, N. J., DECEMBER 1 TO 5

(This exhibit demonstrates the operation of economic laws which determine the commodity price of cotton. The representation of the supply and demand for commodities, gold and paper money by means of colored liquids, and the use of other appropriate analogies make it possible to portray in concrete form what heretofore largely have been abstract conceptions.)

Gas Turbine Power Division Established by A.S.M.E.

THE twentieth professional division of The American Society of Mechanical Engineers was recently established when the Society's Board of Technology approved a petition of the Gas Turbine Co-Ordinating Committee for a change to professional-division status. Organized in 1944 by the Oil and Gas Power Division as a committee of 10 members and charged with co-ordinating efforts of manufacturers, users, and research institutions active in the development of the gas turbine, the Gas Turbine Co-Ordinating Committee has already grown into a committee of 48 members.

Under the guidance of this committee the phenomenal development of the gas turbine and the widespread interest of mechanical engineers in this field of power was reflected regularly in the numerous well-attended technical sessions sponsored at A.S.M.E. national meetings. The divisional status of the committee was presaged recently when at the 1947 national conference of the Oil and Gas Power Division gas-turbine papers tended to unbalance the program and to divert interest from other important technical problems within the purview of the Oil and Gas Power Division.

The new division now forms an independent community of interest whose activities will be directed toward the technology of the gas-turbine power field without upsetting the established and legitimate program of existing divisions.

Objectives of New Division

Among the objectives of the new division, are the following:

1 To constitute a division of The American Society of Mechanical Engineers interested in the improvement of the design and operation of all classes of gas-turbine equipment.

2 To serve and co-operate with other groups and divisions of the Society and with other organizations having related interests in the field of gas turbines, and to co-ordinate technical developments in the field.

3 To provide a common meeting ground where all members of the Society interested in all aspects of gas turbines may gather and exchange experiences and technical data beneficial to the members and the gas-turbine industry as a whole.

4 To promote the exchange of information concerning the principles of gas-turbine design and the supporting data, and to disseminate such information through the presentation, discussion, and publication of papers by individuals, and of reports by technical committees.

5 To encourage experimental and theoretical investigations of the principles of gas-turbine design and allied subjects and to foster improvements in the technique of testing gas-turbine equipment to the end that reliable numerical evaluation of these principles may be effected.

6 To endeavor to obtain papers on advanced technical theories of design, the development of which has not yet reached the stage to warrant consideration in practical applications.

To achieve these objectives the Gas Turbine Co-Ordinating Committee has reorganized to conform to division instructions, and active members in the gas-turbine field whose service formerly could not be effectively utilized are now being appointed to administrative posts within the division. In accordance with established A.S.M.E. procedure the division's Executive Committee will concern itself with soliciting and scheduling papers for Society meetings. A research secretary has been appointed whose responsibility it is to encourage individual research projects. The principal work of the division will be divided among three committees on theory, design, and application. Members of these committees will carry on liaison work with other A.S.M.E. divisions and groups.

More effective administration inherent in divisional status will give renewed impetus to specific projects which have been inaugurated by the Gas Turbine Co-ordinating Committee. Among these are:

1 Listing and abstracting patents pertaining to gas turbines.

2 The compilation of a gas-turbine bibliography.

3 A survey of needs and facilities for the education and training of students and young engineers in the gas-turbine field.

4 Co-operation with, and encouragement of, groups undertaking the formulation of test codes, properties of gases, standards, and terminology for gas turbines.

In all aspects, the Gas Turbine Power Division will endeavor to maintain the A.S.M.E. position in the forefront of the gas-turbine field similar to its position in other fields of mechanical engineering.

The Executive Committee of the Gas Turbine Power Division consists of the following: R. T. Sawyer, chairman, J. T. Rettaliata, J. K. Salisbury, R. A. Browne, J. I. Yellott, and W. J. King.

A.S.M.E. members who wish to be associated with the work of the Gas Turbine Power Division are urged to express their intention in writing to A.S.M.E. Headquarters.

Actions of the A.S.M.E. Executive Committee

At a Meeting Held at Headquarters Aug. 14, 1947

A MEETING of the Executive Committee of the Council was held in the rooms of the Society, Aug. 14, 1947. There were present: Eugene W. O'Brien, chairman; J. N. Landis, vice-chairman; F. S. Blackall, Jr., Alton C. Chick, A. R. Mumford, R. F. Gagg, chairman, Board on Technology; L. N. Rowley, chairman, Publications Committee; E. G. Bailey, nominee for president; D. E. Jahncke, chairman, Junior Committee; C. E. Davies, secretary; and George A. Stetson, editor.

Membership List

Upon recommendation of the Board on Technology, it was voted to distribute membership lists only to members who request copies in writing and to inform members of this arrangement by means of a routine circulation. For convenience of members a request form will be published in Mechanical Engineering prior to publication.

Applied Mechanics Reviews

The secretary reported that a contract for publication of the *Applied Mechanics Reviews* had been signed with the Office of Naval Research, whereby the O.N.R. will contribute financial support for the first two years of publication and the Society will provide editorial services. It is expected that the first issue of the new publication will appear in January, 1948.

Annual Meeting Exhibits

In accordance with actions taken by the 1946 and 1947 Regional Delegates Conference and with the approval of the Board on Technology, it was voted to appropriate a sum of money to finance an educational exhibit at the 1947 Annual Meeting in Atlantic City, N. J. The exhibit will be devoted largely to gas turbines, jet-propulsion devices, and nuclear-energy displays contributed by the Armed Forces.

Joint Code of Ethics for Engineers

Noting approval by the Board on Education and Professional Status of a Joint Code of Ethics for Engineers prepared by the E.C.P.D. Committee on Principles of Engineering Ethics on which William F. Ryan is A.S.M.E. representative, it was voted to review the A.S.M.E. By-Laws for any changes that may be necessary if the Joint Code is adopted, and by letter ballot to refer adoption of the Joint Code to the entire Council.

Codes and Standards

Approval of the following codes and standards between Jan. 1 and June 30, 1947, by the Board of Codes and Standards in accordance with authority vested in it, was noted.

Approved as standards of the Society, and for transmittal to the American Standards Association for approval as American Standards: (1) The proposed American Standard for Shaft Couplings, B49; (2) the proposed American Standard of Machine Pins, B5; and (3) the proposed Addendum to American Standard for Spring Lock Washers, B27.

The proposed A.S.M.E. Standard on Operation and Flow Process Charts was approved as a standard of the Society. A.S.M.E. joint sponsorship for a proposed new standard for V-Belts and V-Belt drives was approved, as well as the withdrawal of A.S.M.E. sponsorship for the proposed new specifications for leather belting.

Resolution of Thanks

On behalf of the Society, a resolution of thanks was voted in appreciation of the contributions made by organizations and individuals of the Chicago Section to the success of the A.S.M.E. 1947 Semi-Annual Meeting in Chicago, Ill.

Lectureships

Upon recommendation of the Meetings Committee it was voted to designate Charles E. Wilson, president of the General Motors Corporation, as the 1946 Towne Lecturer, and George H. Love, president, Pittsburgh Consolidated Coal Company, as the 1947 Thurston Lecturer.

Co-Operative Agreement

Upon recommendation of the Research Committee, it was voted to renew the co-operative agreement between the Department of the Interior for the U. S. Bureau of Mines and the Society for the Research Committee on Furnace Performance Factors for another year. This agreement covers an investigation of ash and slag in boiler furnaces and external corrosion of furnace wall tubes.

Special Research Committees

Upon recommendation of the Research Committee and with approval of the Organization Committee, it was voted to discharge with thanks the special research committees on wire rope, worm gears, and strength of gear teeth.

A.S.M.E. Calendar

of Coming Events

Oct. 6–8, 1947
Petroleum Committee of the A.S.M.E. Process Industries Division Meeting
Houston, Texas

Oct. 20–21, 1947
A.S.M.E. Fuels Division Meeting
Cincinnati, Ohio

Dec. 1–5, 1947
A.S.M.E. Annual Meeting
Atlantic City, N. J.

March 1–6, 1948
A.S.M.E. Spring Meeting
New Orleans, La.

May 30–June 5, 1948
A.S.M.E. Semi-Annual Meeting
Milwaukee, Wis.

Sept., 1948
A.S.M.E. Fall Meeting
Portland, Ore.

Nov. 28–Dec. 4, 1948
A.S.M.E. Annual Meeting
New York, N. Y.

Certificates of Award

Granting of certificates of award to the following were noted: R. J. S. Pigott, retiring chairman, J. R. Carlton, retiring secretary of the Research Committee on Fluid Meters; and A. Ehbrecht, former chairman of the A.S.M.E. Metropolitan Section.

Junior Program

Following a report by D. E. Jahncke, chairman of the Junior Committee, the current status of the program of junior activities was discussed. The President extended thanks to the Junior Committee for the progress being made.

New Student Branch

It was voted to approve the petition for a student branch at Wayne University, Detroit, Mich., at which a mechanical-engineering course had been accredited by E.C.P.D. in 1944.

Regional Change

Letter-ballot approval by the Council was noted of a transfer of the State of Wyoming from Region VII to Region VIII. The change was recommended by the respective vice-presidents to facilitate administration.

Emblems for Past-Presidents

It was voted to provide special emblems for each of the twenty past-presidents and to present an emblem to each retiring president.

Contribution for Junior Committee

It was noted with appreciation that the Dues-Exempt Members' Contributions Committee (Old Guard) had contributed $750 from its fund for the Junior members of the Junior Committee for expenditures incurred in connection with their attendance at meetings of the Committee.

Goddard Rockets

It was noted that the proposed exhibit of Goddard Rockets which was to be held in the lobby of the Engineering Societies Building during October, 1947, has been postponed indefinitely.

Appointments

The following appointments were confirmed: H. C. Dean as honorary vice-president to represent the Society at the Fuel Economy Conference, The Hague, Netherlands, Sept. 2 to 9, 1947.

Stewart E. Reimel, M. A. Julius, H. H. Ehrenburg, Pieter Clausing, and Frederik J. Mans as honorary vice-presidents to represent the Society at the Centenary Celebration of The Royal Netherlands Institution of Engineers, at The Hague, Netherlands, Sept. 22, 1947.

F. D. Herbert, P. T. Sowden, and J. J. Swan, and C. W. Obert, alternate, as tellers of elections of 1948 officers.

The following appointments were approved: L. F. Grant, advisory member, Education Committee; R. M. Johnson, Leslie J. Hooper, and J. T. Rettaliata, Power Test Codes Committee; H. D. Harkins, P. T. C. Committee No. 1 on General Instructions; Marshall H. Howard, Special Research Committee on Furnace Performance Factors; Adm. T. A. Solberg and Capt. J. B. Cochran, Nuclear Energy Application Committee; and William A. Newman, The Engineering Foundation.

Philippines Eager for American Industry

THE Republic of the Philippines is eager to have American industry take an active part in the development of the markets of the Far East, according to H. E. Beyster, member A.S.M.E., president of the H. E. Beyster Corporation, Detroit, Mich., whose consulting firm is serving as technical adviser to the new republic and two of whose engineers are on the Philippine Commission in Tokyo handling claims of reparation from Japan.

An extensive accumulation of technical information is available as a result of a 10-month survey of the Republic's industrial possibilities. The survey covers raw materials, sales possibilities, labor statistics, and distribution through the cottage and general industries.

To promote Philippine industrialization, this survey is being offered to American industry without obligation. For copies of the survey and other technical data about the Islands write to H. E. Beyster Corporation, Industrial Bank Building, Detroit 26, Mich.

Unfired Pressure Vessel Code Hearing Planned

IN the April, 1947, issue of MECHANICAL ENGINEERING announcement was made by the Boiler Code Committee of The American Society of Mechanical Engineers that its Special Committee to Revise Section VIII of the A.S.M.E. Boiler Construction Code has prepared and submitted in draft form the Proposed Revision of Section VIII of the Code, (Unfired Pressure Vessel Code) dated January, 1947. Public hearings were held in May at Houston, Texas, and Los Angeles, Calif., where some 250 representatives exchanged views on the proposed revision.

The Boiler Code Committee will hold another public hearing in the East on the Proposed Revision of Section VIII in the Engineering Societies Building, 29 West 39th Street, New York, N. Y., on November 19, 1947, at 10:00 a.m. The purpose of this hearing is to give all those interested in the proposed revision an opportunity to express verbally their comments. The Boiler Code Committee is particularly desirous of attracting to this meeting all users of the A.S.M.E. Unfired Pressure Vessel Code, such as pressure-vessel manufacturers and users, representatives from the petroleum industry, and inspection authorities.

Those desiring to review the proposed revision may obtain copies from the A.S.M.E. Headquarters, 29 West 39th Street, New York 18, N. Y., at $1 a copy. All those interested are also invited to submit their written comments to the secretary of the Boiler Code Committee.

A.S.M.E. Junior Forum

Compiled and Edited by a Committee of Junior Members, C. H. Carman, Jr., Chairman

A.S.M.E. Junior Committee Initiates First Project

THIS forum for junior members of the Society is the first project of the A.S.M.E. Junior Committee organized at the suggestion of President Eugene W. O'Brien to explore and develop means by which the Society can better serve the needs of junior members and in turn benefit more directly from the ideas and the spirit of its younger members.

Each month in these columns the Junior Committee proposes to discuss professional problems from the point of view of the junior engineer as well as those problems of unionization, professional development, and economic status peculiar to the junior member. The *Junior Forum* is to be a clearing house for junior ideas and a sounding board for junior comment and opinion. The Junior Committee intends to encourage formation of Junior Groups among the Sections and to suggest programs and projects by which these groups can take their places beside older members in the activities of the Society.

Record of Junior Activities

First and always the *Junior Forum* is to be a record of what junior members want from the Society, what they think about professional matters, and what they are doing as young members of the profession. These columns will aim to reflect the current thought of junior members for benefit of junior and older members of the Society who seek to know the young engineer's point of view.

To succeed in these objectives the Junior Committee must rely on junior members, for behind the concept of the *Junior Forum* is the conviction that young engineers are an articulate lot, that they know what they want and why, and that they have the spirit and enthusiasm out of which must come the sustaining ideas for the future. Because professional attainment is an acknowledged goal of all young engineers, the Junior Committee is confident that these objectives can be achieved.

Edited by Junior Members

C. H. Carman, Jr., who is a sales engineer with the Elliott Company, New York, N. Y., and vice-chairman of the Junior Committee, will edit the *Junior Forum* with the aid of an editorial committee of junior members resident in the New York City area. In keeping with the forum idea, letters and comments from junior members on professional matters will be given priority in these columns; but to provide a variety of information helpful and entertaining to the junior member, the editors intend to develop other sources of material to keep the young engineer informed on his chosen profession. Junior members will be invited to review books of significance to young engineers. Papers by juniors otherwise overlooked by the Society will be published in abstract form. News stories of junior activities in the various A.S.M.E. Sections will be reported. Photographs of junior engineers at work will be published and their achievements described. From time to time engineers who have made their mark in the profession will be invited to express themselves on matters of import for the young engineer.

Success Depends on Juniors

This is a broad program whose success must rest on participation in the *Junior Forum* by all junior members of the Society. These columns are yours. They must reflect what you want and what you think. Watch for opinions expressed. If they do not represent your thinking, write to the editors.

Participation in the *Junior Forum* means first, reading the *Junior Forum* regularly, and second, co-operating with the editors by contributing to these columns.

When you have an opinion, express it. The *Junior Forum* is designed for that purpose. A good idea should not die following the lunch-hour bull session. Give it national circulation in these pages. One idea begets many because your professional problems are those of all junior engineers. Your idea may give substance to another felt but not expressed in the mind of some junior member, an idea which may become the seed of some project of value and prestige to the profession. The *Junior Forum* will stand or fall on your interest in it. As a junior member this is your cue.

Unionization of Engineers

Unionization of engineers is a subject about which engineers have well-defined opinions. Some junior engineers may be enjoying the advantages of union membership; others may be chafing under its limitations. Whether unionization has a place in the engineering profession is currently a matter of ferment.

Unionization was the subject of a talk given recently by T. E. Purcell, general superintendent of power stations, Duquesne Power Company, Pittsburgh, Pa., at the Mechanical Engineering Conference of the A.S.M.E. Pittsburgh Section. Because Mr. Purcell expressed considered opinions from the viewpoint of an engineer who has observed the growth and effects on unionization among engineers, the Junior Committee asked him to reconstruct his talk for publication in the *Junior Forum*. His opinions may be at variance with those of some junior engineers. Let us know what you think. Mr. Purcell's talk follows:

Unionization of Engineers, —Yes or No?

The question of the unionization of engineers is of major importance not only to the engineering profession but also to the economic leadership of this nation. It is a matter of personal deep feeling with me and in discussing it I must make it plain that I speak only for myself.

This question is to be faced by every young engineer and we must look at it from his point of view. He has had from four to six years at an engineering college. He is seeking a job with fair competition, with reasonable job security, but primarily with an opportunity for advancement. His problem has been to secure them.

The young engineer knows of the handicap of the depression of the thirties when engineering staffs in the capital-goods field were substantially reduced and industries did not send their representatives to seek new graduates. Salaries were low, jobs were scarce, and opportunity for advancement was nonexistent. There followed the wage stabilization of the forties—the hourly worker increased his take and unionism spread under the National Labor Relations Act. The young engineer, if not drafted into the service, soon found himself engulfed by hourly workers' unions and being bargained for by persons who had little, if any, interest in him. Where had all the creative opportunities gone? Perhaps collective action in a union was a natural consequence.

Advantages Are Transient

What does unionism bring the young engineer? There is usually a transient improvement in wages and provisions for overtime pay. But the engineer has a new boss who bargains for his wages and his welfare, who sets his standard of work, and limits his opportunity. The poor are as good as the good and the good are as good as the poor. There is a leveling process that stifles the ambition of the creative worker.

Experience has shown that the conditions of employment of the young engineer working for an employer has not been too satisfactory. He frequently works for experience, not wages; his advancement is slow—recognition is not forthcoming—and he is usually an introvert not given to complaining. But he does have only one boss and he does have satisfaction in his work.

Young Engineers Need Fair Break

In too many instances industry has been blind to the young engineer's problems and has not given him a fair break. He has made the United States a good place in which to live and no one has given him proper credit. The debt of the public to the engineer remains almost unrecognized. Altogether too many persons talk freely about what the engineer owes the public and too few, if any, talk of what the public owes the engineer.

The engineering societies have only recently begun to consider their responsibilities to this over-all problem. They have made great contributions to the technical life of the engineer and have broadened him socially but they have done little to aid his public prestige and his status with his employer. I believe this is the societies' job. I said so many years ago and with the present program under way there is hope.

The engineer needs a greater measure of recognition on the part of industry and the public. He needs respect and prestige. The public must be made to understand his contribution to public welfare and social advancement. The public realizes it cannot get along without the doctor of medicine. Lawyers, radio and movie nincompoops, and even the corner druggist, have brought about public demand and recognition. It is possible to attain the same for the engineer. Engineers may consider their work to be professional but the public must be made to acclaim it as such.

If this is accomplished, engineers won't need a union. If it is neglected, a union will not do any good.

Profession Not a Union

We must not be confused by transient conditions, we must look to the long term. We must think of the young men to follow. The societies need the ideas and the spirit of youth. The young men need the advisory help of the societies. Let us establish for these young men a profession—not a union.—T. E. PURCELL.

Let's Meet in Atlantic City

Eleven thousand members of the Society are junior members but there are less than 10 junior groups active at the present time. Because junior members are eager to participate in A.S.M.E. affairs, this number can be increased fivefold. The Annual Meeting at Atlantic City will be a good time for hard-headed planning. All junior groups ought to consider sending a representative to the Annual Meeting to meet with the Junior Committee. At such a meeting progress of the Junior Committee could be reviewed and new ideas for improving the *Junior Forum* could be discussed. More about this later.

Guide Book for Juniors

To aid junior members in the formation of groups among the Sections, the Junior Committee is working on a manual of procedure which will tell how to organize such groups and will suggest programs.

How to Be Heard

At this point the Junior Committee walks only in the light of their convictions. They need support from junior members in all the Sections. If the idea of the *Junior Forum* strikes home, write and tell us. If you have anything to say about professional problems write to us about it. Address correspondence to C. H. Carman, Jr., Chairman, *Junior Forum* Editorial Committee, A.S.M.E., 29 West 39th St., New York 18, N. Y.

Student Branches

Eleven Regional Student Conferences Climax Eventful 1947 Student-Branch Calendar

THIRTEEN hundred student members of The American Society of Mechanical Engineers left their campuses during April and May, some traveling distances, to participate in 11 A.S.M.E. 1947 Regional Student Conferences. They responded with enthusiasm to the hospitality and good-fellowship provided by the host colleges in as many states, where they listened to the reading of competitive papers on a variety of subjects, attended luncheons and dinners, cheered prize-winning authors, and inspected industrial establishments and laboratories. During the conferences they formed new friendships, debated the superiorities of their own campuses, football teams, and other things close to the hearts of young men. But of more importance, they gave some time to a serious discussion of A.S.M.E. student problems and plans for the 1948 student-branch program, and when the conferences were over they returned with a foretaste of the satisfactions that come from participation in professional activities, many to graduate, and others to carry on the student program during the new year.

The list of prize-winning authors and papers appears on the following pages.

This was the first time since war restrictions on travel forced postponement of many conferences that all Regions were able to schedule conferences. It was the first time too that the conferences were planned under the new regional grouping of student branches, recently introduced to reduce travel inconvenience for students. In the western regions of the Society, Regions VI, VII, and VIII, two conferences were held, one in the southern area, and the other in the northern area of the Regions, to make it more convenient for students to attend.

Honorary Chairmen Confer

The conferences gave honorary chairmen an opportunity to exchange notes on Society administration of student branches. They noted with satisfaction the careful planning and hospitality of host colleges and that beginning with the October issue, MECHANICAL ENGINEERING, complete with advertising, would be mailed direct to each student member. They discussed the formation of student-engineer councils in areas where several engineering schools were in easy communicating distance of each other, and agreed to review the scoring sheet used for grading student papers for possible revision. Methods for increasing conference attendance and improving quality of papers were also discussed.

New England Colleges Meet at Yale

More than 150 student members registered at the 1947 Region I Student Conference held

ASME
CONVENTION
INFORMATION
REGISTRATION

REGISTRATION AT THE REGIONAL STUDENT CONFERENCE OF THE SOUTHWESTERN COLLEGES OF REGION VII HELD AT THE UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF., MAY 2 AND 3, 1947

(*Seated, left to right:* S. Knapp and Miss B. J. Short, University of California; *standing, left to right:* W. J. Walker, University of Southern California; E. Beder, California Institute of Technology; I. Diamond, University of California; J. T. Turbeville; and E. K. Springer, honorary chairman, University of Southern California; J. B. Werner and P. R. Conrath, California Institute of Technology.)

1947 A.S.M.E. Regional Student Conference Prize Winners

REGION I YALE UNIVERSITY, NEW HAVEN, CONN., MAY 2–3, 1947

Attendance: 164 Papers presented: 13

Prize	*Recipient*	*Title of Paper*	*College*
First	Howard E. Wolff	Influence of Worker Fatigue on Industry	Tufts College
Second	Harold W. Curtis	Dust Collections	Northeastern Univ.
Third	Robert L. Washburn	Comparison of Open and Closed Cycles for Gas-Turbine Operation	Clarkson College of Tech.
Fourth	Robert M. Neary	The Calculation of Certain Performance Data in the Design of a Jet Turbine Engine	Brown Univ.
Old Guard	Albert I. Brayman	High-Temperature Hot-Water Systems	Mass. Inst. of Tech.

REGION II COLUMBIA UNIVERSITY, NEW YORK, N. Y., MAY 10, 1947

Attendance: 135 Papers presented: 6

Prize	*Recipient*	*Title of Paper*	*College*
First	Jerome H. Mandel	An Introductory Study of Color in Industry	College of the City of N. Y.
Second	Joel Miller	Should Engineers Organize?	Poly. Inst. of Brooklyn
Second	Seymour Himmel	Vibrations and Balancing Machines	College of the City of N. Y.
Old Guard	Roy Greene	The Five-Year Curriculum in Mechanical Engineering	Cooper Union School of Engrg.

REGION III VILLANOVA COLLEGE, VILLANOVA, PA., APRIL 17, 1947

Attendance: 124 Papers presented: 13

Prize	*Recipient*	*Title of Paper*	*College*
First	Andrew W. Anderson	Theory and Application of Combustion Gas Turbines	Drexel Inst. of Tech.
Second	James F. Porter, Jr.	Job Evaluation	Johns Hopkins Univ.
Third	Ronald E. Bowles	Jets and Small Airplanes	Univ. of Maryland
Fourth	Kenneth C. Johnson	Laminated Plastics	Lehigh Univ.
Old Guard	Joseph E. Riegel	An Energy Balance	Pennsylvania State College

REGION IV GEORGIA SCHOOL OF TECHNOLOGY, ATLANTA, GA., APRIL 6–8, 1947

Attendance: 190 Papers presented: 13

Prize	*Recipient*	*Title of Paper*	*College*
First	Walter B. King	Design of a Water-Injection System for Automotive Engines	Univ. of Florida
Second	Milton S. Hochmuth	Liquid Rockets	Georgia School of Tech.
Third	William C. Banner	Coal-Mining Methods	Virginia Poly. Inst.
Old Guard	Perry V. Lane	Flying Artillery	Univ. of Tennessee
Fifth	Clifford L. Sayre	Shallow-Water Diving Equipment	Duke Univ.

REGION V CASE INSTITUTE OF TECHNOLOGY, CLEVELAND, OHIO, APRIL 21–22, 1947

Attendance: 63 Papers presented: 8

Prize	*Recipient*	*Title of Paper*	*College*
First	Victor N. Lagarias	History and Future of Steam for Automotive Power	Ohio State Univ.
Second	Charles F. Derr	Measurement of Low Air Velocities	Michigan State College
Third	Walter H. Friedlander	Methods of Locating and Eliminating Machine Noise	Univ. of Cincinnati
Fourth	Alexander Fino	Methods of Storing Volatile Liquids	Univ. of Pittsburgh
Old Guard	John E. Webster	Machinability	Case Institute of Tech.

REGION VI NORTHERN TIER—UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINN., MAY 19–20, 1947

Attendance: 109 Papers presented: 9

Prize	*Recipient*	*Title of Paper*	*College*
First	Patrick D. O'Connell	Preparation of Potato Flour	Univ. of North Dakota
Second	Charles Griffin	Engineering Citizenship	Northwestern Univ.
Third	Kenneth D. Simon	Our Foundations Are Crumbling	Univ. of Minnesota
Fourth	Ralph A. Mortensen	Color Dynamics—Paint Your Way to Greater Production	Univ. of Notre Dame
Old Guard	Robert Nelson	The Development of the Gas Turbine	South Dakota State College

REGION VI SOUTHERN TIER—PURDUE UNIVERSITY, LAFAYETTE, IND., APRIL 28–29, 1947

Attendance: 139 Papers presented: 8

Prize	*Recipient*	*Title of Paper*	*College*
First	Clarence R. Apitz	Thickness and Density Measurement by Reflected Gamma Rays	Purdue Univ.
Second	John B. Mackey	Sintered Carbides	Univ. of Illinois
Third	Robert W. Baebler	Labor Pains	Univ. of Missouri
Fourth	Paul B. Henderson	Power From the Wind	Washington Univ.
Old Guard	Hugh B. Abbott	The Design of a Venetian-Blind Slat-Forming Machine	Univ. of Kentucky

REGION VII PACIFIC NORTHWEST—OREGON STATE COLLEGE, CORVALLIS, ORE., APRIL 24–26, 1947

Attendance: 60 Papers presented: 7

Prize	*Recipient*	*Title of Paper*	*College*
First	Lee Miller	An Improved Trailer-Home Layout	Univ. of Idaho
Second	Donald Benz	Application of the Heat Pump	Oregon State College
Third	George A. Medley	Will Your Job Shop Go Broke?	Washington State College
Fourth	Donald Anderson	Power Plant of the Future for Light Airplanes	Univ. of Washington
Old Guard	Richard E. Holt	Controlled Distortion	Univ. of Washington

REGION VII PACIFIC SOUTHWEST—UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF., MAY 2–3, 1947

Attendance: 46 Papers presented: 8

Prize	*Recipient*	*Title of Paper*	*College*
First	Gordon P. Hawkins	Naval Boiler Design	University of California
Second	William J. Walker	Ceramic Materials for Turbine Blades	Univ. of Southern California
Third	Alvin H. Storch	Home Air Conditioning	Univ. of Santa Clara
Fourth	Leonard S. Levinson	Induction Heating of Metals	Univ. of Southern California
Old Guard	James R. Conway	Wind-Tunnel Tests of Sailing Rigs	Univ. of Santa Clara

REGION VIII SOUTHERN—UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., APRIL 28–29, 1947

Attendance: 220 Papers presented: 15

Prize	*Recipient*	*Title of Paper*	*College*
First	Herbert N. Hickok	A Propeller Pitch Indicator	Univ. of Texas
Second	Chester A. Peyronon	The V-2 Rocket	Tulane Univ.
Third and Old Guard	Donald W. Coulson	Instrument Landing Systems for Aircraft	Kansas State College
Fourth	Raymond A. Porter	The Flight Engineer	Oklahoma A. & M. College
Fifth	Joseph W. Morledge	Dynamic Balancing of Locomotive Drive	Rice Institute
Sixth	Robert D. Slonneger	Elementary Nomography	Univ. of Oklahoma
Seventh	Richard D. Hillyer	The Indicator Diagram and Its Relation to Diesel-Engine Study	Univ. of Oklahoma
Eighth	Cecil Dotson	Job Evaluation	Southern Methodist Univ.
Ninth	George S. Johnson	High Vacuum Methods	Univ. of Arkansas
Tenth	Stephen D. Hadley	Engineering Education	Univ. of Kansas
Eleventh	Luther H. Waller	Problems of Refrigerated Transport	Tulane Univ.
Twelfth	Clarence Eaton	Peak Day-Load Analysis of the Lone Star Gas Co.	Southern Methodist Univ.

REGION VIII ROCKY MT., STUDENT CONFERENCE, UNIVERSITY OF UTAH, APRIL 21–22, 1947

Attendance: 70 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Jack M. Hardgrave	Turbo Jets—Jumo 004	New Mexico State College
Second	Reed G. Bills	Development Work in Parachute Artillery	Univ. of Utah
Third	Charles A. Einarsen	Possibility of Oil-Shale Development in Colorado	Colorado School of Mines
Fourth	Arthur M. Riley	The Manufacture of Small-Caliber Ammunition	Colorado A. & M.
Fifth	Eugene Parks	Coal-Fired Gas Turbine	New Mexico State College
Old Guard	Robert E. Breisch	Piping Procedure	Univ. of Wyoming

at Yale University, May 2 and 3, 1947. After a morning and afternoon of campus inspections and a dinner at which the students were welcomed by Prof. W. J. Wohlenberg, chairman, department of mechanical engineering, Yale University, the first technical session was begun. Two other sessions were held the following day. The conference ended with a dinner on Saturday, May 3, at which prizes were presented. C. B. Veal, member A.S.M.E., of the Co-Ordinating Research Council, New York, N. Y., spoke on "Research—Opportunity and Challenge." Mr. Veal's paper was published in MECHANICAL ENGINEERING for September, 1947.

Several suggestions to improve conference procedure were made. One was that some affair of a social nature be planned for the evening of the first day of the conference. This, it was said, would help student delegates to become acquainted more quickly. It was also proposed that a plan of procedure be drawn up to aid host colleges in planning future conferences.

The University of Rochester and the Rensselaer Polytechnic Institute, while not officially in the A.S.M.E. Region I, sent delegations to the New England conference to reduce traveling expenses. The group was heartily welcomed and was extended a standing invitation to participate in New England conferences.

L. S. Marks at Region II Conference

Student branches of Region II met at Columbia University, New York, N. Y., on May 10, 1947. Six student papers were read and following a short recess, Prof. Lionel S. Marks, Fellow A.S.M.E., spoke to the conference on "Jet Propulsion and Civil Aviation." He was followed by John Gaillard, member A.S.M.E., of the American Standards Association, who spoke on "Standardization in the Mechanical Industries." In the evening a dinner was held at which A. R. Mumford, vice-president, A.S.M.E. Region II, presented the awards. Walter Rautenstrauch, member A.S.M.E., professor emeritus, Columbia University, addressed the students on "Creative Human Relations."

Region III Meets in Philadelphia

Initiative on the part of Region III made the Region III Student Conference held at the Hotel Penn Sheraton, Philadelphia, Pa., April 17, 1947, a fruitful event not only for the students, but for the Junior Group of the A.S.M.E. Philadelphia Section and for local industry. The Junior Group recognized in the conference an untapped field for service, and industry saw in the event an opportunity for observing the 1947 group of mechanical-engineering talent in action. Both acted energetically, the Juniors co-operating with Villanova College as hosts of the conference, and industry sending 42 representatives along with souvenirs and catalogs for the students.

Albert Schade, chairman of the Junior Group, A.S.M.E. Philadelphia Section, extended a welcome to the students and explained aims and programs of Junior Groups of the Society. The Junior Groups, he said, stand ready to welcome the student into the A.S.M.E. after graduation. Junior members serve as the best contacts for seniors because they are not much older than the recent graduates and can remember their own struggles.

The Baldwin Locomotive Works, Baldwin, Pa., contributed 100 SR4 strain gages valued at $1.50 each, and 20 explanatory catalogs for distribution among the students.

At the banquet which followed reading of the student papers, Eugene W. O'Brien, president A.S.M.E., spoke on "You Who Carry On." President O'Brien compared the tremendous opportunity available to American young men with the plight of the youth of other nations. He admonished the students that in the years ahead they would be trading their youth for experience. He urged them to develop their contacts and to increase their articulateness. One without the other was useless, he said. The A.S.M.E. stands ready to help in the development of all three—experience, contacts, and articulateness. Following his talk, President O'Brien distributed prizes to winning students.

Junior members and industry, by co-operating in the Region III conference, helped to broaden the concept of the student conference from an event of academic interest to one in which the student for the first time in his career was brought intimately in contact with the two most important elements of his professional career, the Society which will help him to serve himself, and industry which will enable him to serve others.

Atlanta Section Host to Region IV

Student members from 11 southern engineering colleges attended the Region IV Student Conference held at the Georgia School of Technology, Atlanta, Ga., April 6 to 8, 1947. The conference was sponsored by the Regional Administrative Committee and the A.S.M.E. Atlanta Section.

STUDENT AUTHORS AT THE 1947 A.S.M.E. REGION IV STUDENT CONFERENCE HELD AT THE GEORGIA SCHOOL OF TECHNOLOGY, ATLANTA, GA., APRIL 6 TO 8, 1947

(*Left to right:* Frank S. Manning, Mississippi State; Walter B. King, first prize winner, University of Florida; W. C. Banner, third prize winner, Virginia Polytechnic Institute; P. V. Lane, fourth prize winner, University of Tennessee; A. W. Futrell, Jr., North Carolina State College; Clifford L. Sayre, fifth prize winner, Duke University; M. S. Mochmuth, second prize winner, Georgia Tech.; and E. Melton Brown, Vanderbilt University.)

Scenic tours of Atlanta, an informal dance in the Georgia Tech gymnasium, and trips to Atlanta industrial plants, in addition to the student-paper sessions, made up the three-day program.

The first technical session was one sponsored by the Atlanta Section. Three papers of special interest to students were presented by members of the Society. P. B. Place, Combustion Engineering Company, spoke on "Steam Purification." He was followed by G. D. Lobingier, manager of the graduate-student training department of the Westinghouse Electric Corporation, who described his company's training programs. D. Rogers McCullough, director of the power-pile division at Oak Ridge, Tenn., spoke on "Power From Atomic Sources."

Eugene W. O'Brien, president A.S.M.E., and E. E. Williams, vice-president, A.S.M.E. Region IV, were on hand to talk to the delegates. President O'Brien was the main speaker at the banquet at which prizes were presented.

Region V Meets in Cleveland

The Region V Student Conference was held at the Case Institute of Technology (formerly Case School of Applied Science), Cleveland, Ohio, April 21 and 22, 1947.

Following the first session, the delegates inspected the campus and laboratories of the host college. Later in the afternoon a visit was made to the Cleveland Graphite Bronze Company. Edwin Crankshaw, member A.S.M.E., assistant chief engineer of the plant, talked to the group on the importance of bearings and the method of manufacture observed during their inspection of the plant. Following a showing of a motion picture on bearing manufacture, the group attended a dinner as guests of the Cleveland Graphite Bronze Company.

The evening was spent at the Nela Park Lighting Institute where the group enjoyed a tour of the Institute and a demonstration of the latest development in the field of industrial lighting.

The conference ended with a luncheon at the Tudor Arms Hotel at which prizes were presented.

Region VI Holds Two Conferences

Two student conferences were held in Region VI to accommodate student branches in the northern and southern schools of the Region.

The southern group met at Purdue University, April 28 and 29, 1947. Eight engineering schools were represented. The first day of the conference was reserved for presentation of student papers.

One of the features of the program was the banquet at which Mrs. Bruce O. Buckland, consultant in heat transfer and fluid flow for the General Electric Company, spoke on "Some Heat-Transfer Problems in Electric Apparatus."

The delegates made a tour of the Lafayette plant of the Aluminum Company of America on the following day, and the conference came to an end with a luncheon at which T. S. McEwan, vice-president, A.S.M.E. Region VI, presented prizes to students of winning papers.

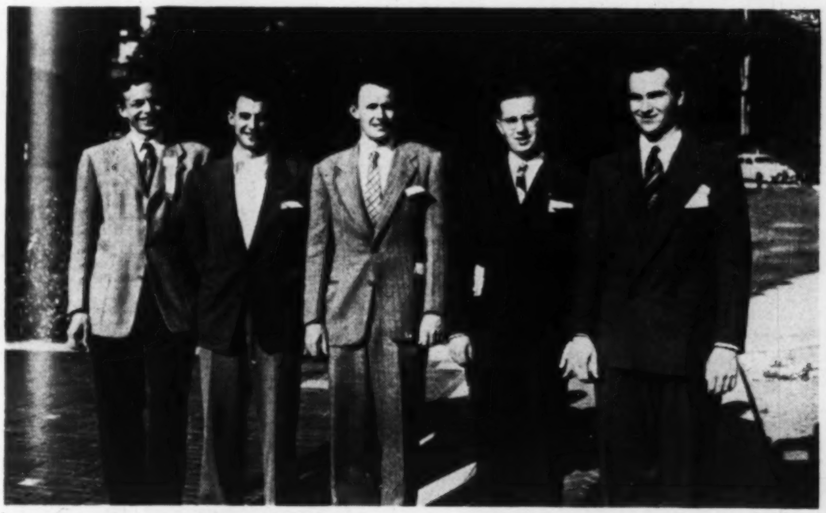
The northern group met at the University of Minnesota, May 19 and 20, 1947. More than a hundred students, representing 11 schools, attended. A high light of the carefully planned program was the banquet on Monday, May 19. Piano and vocal soloists provided entertainment.

A talk on nuclear physics was given by Frank Oppenheimer, assistant professor of physics, University of Minnesota.

The conference ended with a luncheon at which Vice-President McEwan was on hand for presentation of awards.

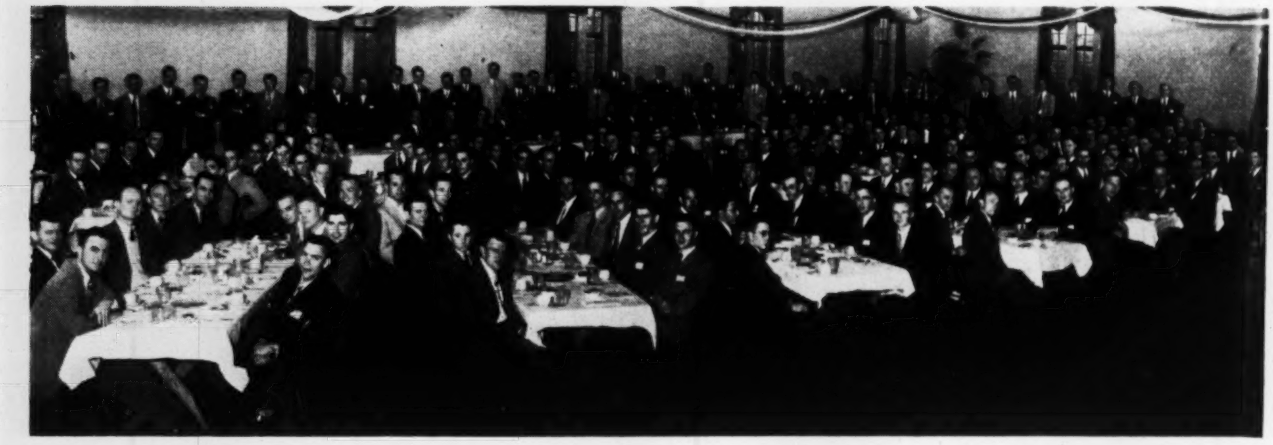
Stimulating Conference in Region VII

Because of the great distance of the Far West, Region VII scheduled two student conferences. Northern schools met at the Oregon State College April 24 to 26, and the southern



STUDENT CHAIRMEN AT THE REGION VII PACIFIC S. W. STUDENT CONFERENCE AT THE UNIVERSITY OF CALIFORNIA

(*Left to right:* D. E. Welton, University of California; R. Blumenthal, University of Southern California; J. H. Sampson, Stanford University; J. B. Werner, California Institute of Technology; and J. R. Conway, University of Santa Clara.)



DINNER MEETING OF THE 1947 REGIONAL STUDENT CONFERENCE OF THE SOUTHERN COLLEGES OF A.S.M.E. REGION VIII HELD AT THE UNIVERSITY OF OKLAHOMA, NORMAN, OKLA., APRIL 28 AND 29, 1947

schools met at the University of California, Berkeley, Calif., May 2 and 3, 1947.

The Pacific Northwest Conference at Portland, Ore., attracted more than 60 students from four engineering schools. The first day was devoted largely to technical sessions in which each school presented two papers. Between sessions delegates were shown around the Oregon State College mechanical-engineering laboratory and the industrial-arts shops. In the evening a banquet was held in the Corvallis Hotel where the delegates exchanged ideas and discussed A.S.M.E. problems.

The next morning a large group of delegates left Corvallis for a one and a half day field trip to Portland and vicinity. On the way the group inspected the municipal Diesel-electric power plant at McMinnville, Ore., and the Crown-Zellerbach paper mill at West Linn, Ore. A visit was also made to the Hyster Company where the group observed mass-production technique applied on a small scale.

A joint banquet with the A.S.M.E. Oregon Section was held on Friday at the Old Heathman Hotel. Judge Charles W. Redding was the main speaker. His subject was "The Engineer's Public Responsibility as a Citizen."

The conference ended with a general feeling of satisfaction among the delegates. The exchange of ideas is expected to stimulate greater interest in A.S.M.E. student-branch affairs at the schools.

Ninth Conference for Pacific Southwest

The Pacific Southwestern schools in Region VII held their ninth annual student-branch conference at the University of California, Berkeley, Calif., May 2 and 3, 1947. Forty-six representatives from six universities participated in the technical sessions, social events, and field-inspection trips.

Immediately after the first technical session the delegates were taken to the 184-in. cyclotron. The various parts of the huge instrument were explained and samples of material made radioactive by bombardment from the cyclotron were shown.

Following the inspection, a banquet was held at the Shattuck Hotel. The principal speaker was Prof. Wilson M. Powell whose subject was "Why Build a Cyclotron?"

Reading of the student papers was completed on Saturday and awards were conferred at the luncheon that followed. J. Calvin Brown, vice-president, A.S.M.E. Region VII, made the presentations.

The conference was concluded with a trip to the Pacific Gas and Electric Company in Oakland, Calif.

Region VIII Has Largest Conference

A record number of prizes were offered and won at the A.S.M.E. student conference of the southern schools in Region VIII, held at the University of Oklahoma, April 27 to 29, 1947. In addition to the usual prizes, the A.S.M.E. Mid-Continent Section offered four prizes amounting to $100, and several business organizations offered $10 prizes and engineering handbooks.

More than 200 students took part in the technical sessions and social events.

The problem of future student conferences in Region VIII was thoroughly discussed during the conference. Schools in the Region are so isolated that it is difficult to assemble students for regional meetings. It was the concensus that one meeting was not practicable because of the great distances involved. It was suggested that the schools within the Region be divided into three groups, each to hold its own annual student-branch conference.

The Rocky Mountain Student Conference of A.S.M.E. Region VIII met at the University of Utah, Salt Lake City, Utah, April 21 and 22, 1947.

Commencing with a field trip to the open-pit copper mine at Bingham, the conference continued during the first day with a luncheon at noon, and reading of student papers in the afternoon. A banquet was held at the Newhouse Hotel at which Miss Betty A. Beck, student member from the University of Colorado, presided.

The second day of the conference was devoted to reading papers in the morning, an award luncheon at noon, and a field trip to the Geneva steel plant in the afternoon.

Seventy student members from eight engineering schools participated in the 1947 conference.

A.S.M.E. Sections

Coming Meetings

Metropolitan:

October 2. Engineers' Forum, Room 1101[1] at 7:30 p.m. Subject: "Objectives of Engineers' Forum—Your Professional Development."

October 9. Industrial Instruments and Regulators Forum, Room 1101,[1] at 7:30 p.m. Subject: "Specifying and Evaluating of Performance of Servomechanism."

October 9. Woman's Auxiliary—Engineering Woman's Club, 2 Fifth Avenue at 1 p.m.

October 10. Room 501*a*[1] at 7:30 p.m. Subject: "Vagaries of Fuel-Burning Equipment From a Boiler Salesman's Viewpoint," by N. J. Connor, assistant manager, New York District, Babcock & Wilcox Co., New York.

October 14. Materials Handling Forum, Room 1101,[1] at 7:30 p.m. Subject: "Electrical Devices for Materials Handling Equipment," by C. B. Risler, materials handling application engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.

October 16. New Jersey Division, Wood-Ridge, N. J., at 7:30 p.m. Visit to Wright Aeronautical Corporation, Wood-Ridge, N. J.

October 22. Engineers' Forum, Room 501 B and 501 C[1] at 7:30 p.m. Subject: "Engineers' Registration Act," by a member of the New York State Board of Engineering Examiners.

October 24. Engineering Societies Building at 6 p.m. Metropolitan Section Night.

October 30. General Interest Meeting, Room 502,[1] at 7:30 p.m. Subject: "United States Navy Submarine Development," by a prominent Naval Officer.

Note to Section Secretaries

Notices of coming A.S.M.E. meetings must be received at Society Headquarters on or before the eighth of the month preceding the month of publication to appear in this column.

---

[1] Engineering Societies Building, 29 West 39th St., New York, N. Y.

To Further World Engineering Conference

FURTHERANCE of plans for a permanent World Engineering Conference, in which American engineers are playing a leading role, will be the order of business at a meeting of the council and executive board of the Conference in Zurich, Switzerland, September 9 to 12. Stewart E. Reimel, secretary of the Committee on International Relations of the Engineers Joint Council, will attend this meeting. He will represent the United States National Committee for the World Engineering Conference.

Provisional plans for the international technical body were made at a meeting of engineers and scientists held in Paris last September. The U. S. committee is sponsored by three of the leading engineering societies in this country, the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the American Institute of Chemical Engineers. Some fifty or more other U. S. engineering societies will be invited to join.

Eight other nations signed the minutes at the Paris meeting, and others are expected to come in, making the project world-wide in scope. The advancement of engineering knowledge and the exchange of technical information among countries for the benefit of all are aims of the Conference.

Mr. Reimel will remain in Europe to represent The American Society of Mechanical Engineers at the centenary of the Royal Netherlands Institution of Engineers at The Hague late in September.

A.S.M.E. Handbook Board Meets

THE Metals Engineering Handbook Board met at Cape Vincent, N. Y., Aug. 18 and 19, 1947, where they were the guests of the New York Air Brake Company.

The handbook, planned especially for the design engineer and design draftsman, has made satisfactory progress during the past months as shown by the number of manuscripts submitted by those responsible for the different sections. The five technical sections into which the book is divided will give the engineer and draftsman ready access to the information on metals required in design.

The section on design and that on the properties of metals have been subdivided so that the various phases of engineering are each treated separately and the properties of each metal considered are co-ordinated to best advantage for reference purposes.

The Working Committee gave a report of progress made since the last board meeting and made definite recommendations as to the size of the volume and the style to be followed in its composition. These recommendations were accepted by the Board.

L. K. Sillcox, Fellow A.S.M.E., vice-president of the New York Air Brake Company, and chairman of the Handbook Board, was host at "Road's End" the Company's shore cottage at Cape Vincent.

A.A.A.S. to Hold 114th Meeting in Chicago, Dec. 26–31

FIFTY societies will meet with 15 sections of the American Association for the Advancement of Science at its 114th meeting to be held in Chicago, Ill., December 26–27, 1947.

Section M (Engineering) plans to meet Dec. 29 and 30. The present program arrangements, under the direction of the Section secretary, Frank D. Carvin, member A.S.M.E., Newark College of Engineering, call for a series of general technical papers on engineering and a symposium on "Limnological Aspects of Water Supply and Waste Disposal." Theodore A. Olson, school of public health, University of Minnesota, will serve as chairman of the symposium which was organized in co-operation with G. L. Clark, Harvard University, secretary of the Limnological Society of America.

The Chicago Technical Societies Council, represented by D. L. Tabern, Abbott Laboratories, is co-operating with Section M in sponsoring the program. J. T. Rettaliata, member A.S.M.E., Illinois Institute of Technology, is chairman of the local committee in charge of meeting details.

A.S.M. Elects 1947–1948 Officers

AT a meeting of the American Society for Metals, Cleveland, Ohio, the following were nominated to serve for 1947–1948: Francis B. Foley, Philadelphia metallurgical research head, for president; Dr. H. K. Work, manager of research and development, Jones and Laughlin Steel Corporation, Pittsburgh, Pa., for vice-president; F. L. Spanagel, engineer, industrial department, Rochester Gas and Electric Corporation, Rochester, N. Y., for treasurer; Dr. E. G. Mahin, professor of metallurgy and head of the department, Notre Dame University, and C. M. Carmichael, vice-president, Stainless Steel and Alloys Division, Shawinigan Chemicals, Ltd., Montreal, Que., Canada, to serve for two-year terms as national trustees of the society.

R. E. Dougherty Nominated 1948 A.S.C.E. President

RICHARD E. DOUGHERTY, White Plains, N. Y., vice-president of the New York Central Railroad, was nominated as the 1948 president of the American Society of Civil Engineers, at the summer convention of the A.S.C.E. held in Duluth, Minn., June 16–18, 1947.

Mr. Dougherty, a graduate of New York City's public schools, attended the College of the City of New York three years and was graduated from Columbia University in 1901.

Mr. Dougherty has been in the service of the New York Central System since 1902 and was engineering assistant to the president of the lines prior to his election to the office of vice-president in charge of improvement and development on February 1, 1930.

Meetings of Other Societies

October 1–2
Army Ordnance Association, annual meeting, Waldorf-Astoria Hotel, New York, N. Y. (Second day's session will be held at Aberdeen Proving Grounds, Md.)

October 1–2
American Society of Tool Engineers, semi-annual meeting, Hotel Statler, Boston, Mass.

October 1–2
Institute of the Aeronautical Sciences, Inc., air transport meeting, New York, N. Y.

October 2–4
Society of Automotive Engineers, Inc., national aeronautic meeting and aircraft engineering display, Baltimore Hotel, Los Angeles, Calif.

October 6–8
Technical Association Pulp and Paper Industry, alkaline pulping meeting, Hotel Battery Park, Asheville, N. C.

October 6–8
American Gas Association, annual meeting, Cleveland, Ohio

October 6–10
National Safety Council, Inc., 35th national safety congress and exposition, The Stevens and Congress Hotels and the Palmer House, Chicago, Ill.

October 15–17
American Society of Civil Engineers, fall meeting, The Hotel Roosevelt, Jacksonville, Fla.

October 18–24
American Society for Metals, national metal exposition and congress, International Amphitheatre, Chicago, Ill.

October 24–25
Engineers' Council for Professional Development, 15th annual meeting, Mt. Royal Hotel, Montreal, P. Q., Canada

October 27–29
American Gear Manufacturers Association, 1947 fall meeting, Edgewater Beach Hotel, Chicago, Ill.

October 27–29
American Mining Congress, metal-mining convention, El Paso, Texas.

October 29–30
National Machine Tool Builders' Association, annual meeting, Edgewater Beach Hotel, Chicago, Ill.

A.S.M.E. Master-File Information

Please Print

Check Mailing Address

Name...
Last First Middle

Home Address.. ☐
Street City Zone State

Name of Employer..

Address of Employer.. ☐
Street City Zone State

Product or Service..

Position or Title...

Notify Headquarters Promptly of Future Changes

Keep Your A.S.M.E. Records Up to Date

HEADQUARTERS depends on its master membership file for answers to hundreds of inquiries daily pertaining to its members. All other Society records and files are kept up to date through changes processed through it. The listings in future A.S.M.E. Membership Lists will be taken directly from the master file. It is important to you that it lists your latest mailing address and your current business connection.

The mailing form on this page is published for your convenience. You are urged to use it in reporting recent changes.

Your mailing address is important to Headquarters. Please check whether you want your mail sent to home or office address.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

EXECUTIVE ENGINEER, mechanical graduate, age 49. Experienced light and heavy machinery production, pumps, compressors, mining equipment, product design, and tooling. Plant engineer. Superintendent plant 1500. Interested in administration, top executive assistant, or chief-engineer position. Me-215.

PLANT MANAGER-SUPERINTENDENT, METAL STAMPINGS. Pressed and deep-drawn. Ferrous and nonferrous metal, including the hot-press-forming and spinning of magnesium. Straight-line assembly on mass-production basis. Lacquered, painted, and plated finishes. Creative ability to develop new lines adapted to present equipment. Cost analysis and reduction. Unusual ability to handle labor. Me-216.

MECHANICAL ENGINEER, B.Sc., 1946, Queen's University, Canadian, age 23; one year instructing in thermodynamics and conducting mechanical-engineering laboratory; experience as compressor engineer; desires production or sales, New York State. Me-217.

PLANT MANAGER'S CONSULTANT OR SUPERINTENDENT of power and maintenance, age 38, married. Twenty years' theoretical and practical experience with public utilities and chemical plants, specializing in water conditioning, modernization of steam-power plants and improved maintenance methods, excellent personnel and union relations. Available immediately. Me-218-477-D-15-San Francisco.

MECHANICAL ENGINEER, graduate. Excellent background in design, development, testing, and research. Would continue in field or use experience to teach laboratory procedures, shop methods, drafting. Suburban Boston preferred but not essential. Me-219.

PRODUCTION ENGINEERING or supervisory research position preferred by general engineer, B.S. and M.S. degrees; 30, married. Supervisory experience. Seven-year background in research, development, preproduction of precision-electromechanical equipment. Mathematician, stress analyst. Me-220.

MECHANICAL ENGINEER, 13 years' engineering and laboratory experience with one company in application of room- and high-temperature alloys. Interested in staff position to contribute of product improvement and cost reduction. Me-221.

MECHANICAL ENGINEER, graduate, age 25, married. Four years' diversified experience in design, testing, and stress analysis. Desires position as designer or test engineer. Available October. Location, immaterial. Me-222.

MECHANICAL ENGINEER, Tau Beta Pi. A year and a half's experience in heat-transfer research by electrical analogy. Also considerable experience in electronic sealing of thermoplastics. Possesses executive ability and initiative. Me-223.

MECHANICAL ENGINEER, graduate, experienced design and production conveyer equipment and sheet-metal fabrication, including welding operations; also methods, plant layout, cost control. Desires permanent position in New York metropolitan area. Available January 15, 1948. Me-224.

MECHANICAL ENGINEER, 13 years' experience in design, development, research, materials specifications, and engineering supervision, in the portable electric-tool and marine-accesories fields. Now in complete charge of engineering and manufacturing. Me-225.

MECHANICAL ENGINEER, age 24, single, experienced with internal-combustion-engine testing, design of instruments and controlling devices, cooling towers, vibration analysis, and strength tests on aircraft. Also materials engineer. Minimum, $250-$275 a month. Location preferred, California. Me-226-478-D-5.

ENGINEERING EXECUTIVE, chemical engineer, 20 years' broad experience in project management; supervision of process development, equipment design and application; administration of plant design, construction, and operation. Me-227.

POSITIONS AVAILABLE

MECHANICAL ENGINEER, either recent gradu-

(*A.S.M.E. News continued on page 886*)

---

[1] All men listed hold some form of A.S.M.E. membership.

Double Check ON BOILER WATER LEVELS

YARWAY
H
N
REMOTE LIQUID
LEVEL INDICATOR

Here's an instrument that brings boiler water level indication right down to eye level, on the instrument panel or other convenient location—a perfect *check* on hard-to-see overhead gages.

Yarway's Remote Liquid Level Indicator is always accurate because it is operated by the boiler water itself—by the pressure differential between a constant head of water and the varying head in the boiler drum. Action is instant, constant, frictionless. *There are no stuffing boxes.* Indicating mechanism is never under pressure. Mechanism is perfectly balanced on jewelled bearings outside of the pressure chamber.

From coast to coast, the Yarway Indicator is meeting with enthusiastic approval. One prominent user said, "If I couldn't get another one like it, I wouldn't sell the one I have for many times its cost!"

More than 2500 have already been bought for indicating boiler water level, feed heater water level, and superheater pressure differential. For complete description of operating details, write for Bulletin WG-1822.

YARNALL-WARING COMPANY
108 Mermaid Avenue Philadelphia 18, Pa.

Typical instrument panel mounting of Yarway Indicator in rubber manufacturing plant.

One of two Yarway Indicators mounted on end of instrument panel in boiler room of Western utility.

YARWAY REMOTE LIQUID LEVEL INDICATOR

ate or one with 1 to 2 years' experience, preferably single, for work in South America, on plant layout and putting into operation series of soft-drink plants. Training period in New York. $4800 year plus expenses. W-9513.

Production Engineer, 35–45, mechanical graduate, with machining, stamping, plating, and assembly supervisory experience, to take charge of production for manufacture of vending machines. $8000–$10,000 year. New York metropolitan area. W-9527.

Mechanical Engineer, graduate, with experience in design and development of heavy materials-handling equipment, as ore bridges and cranes. Must be capable of rapid, accurate work. Salary open. Write giving experience, design achievements, age, education, etc. Pittsburgh area. W-9528.

Industrial Engineer, 35–40, preferably with varied experience including supervision in metalworking; some knowledge of precision grinding and/or carburizing and heat-treating, for manufacturer of ball bearings. Good opportunity. Write stating experience salary desired, etc. Eastern Pennsylvania. W-9531.

Industrial Engineer, mechanical graduate, 35–45, with at least 10 years' manufacturing experience, to supervise methods work, analyze operations, plan new layouts, and improve existing facilities in electric-cable-manufacturing plant. $8000 year. East. W-9535.

Smoke-Abatement Engineer with technical training and experience in theory and practice of combustion engineering. $6000 year. Maryland. Interviews, New York, N. Y. W-9559.

Time-Study and Methods Engineer, 28–35, preferably someone who has come up through shop and is familiar with common machine tools including automatics. If necessary, will teach time-study requirements. Write giving full details including salary. Eastern Pennsylvania. W-9653.

Plant Engineer, 35–40, mechanical graduate, with at least 10 years' experience in process plant operation and maintenance, to take charge of food-processing equipment. $6000 year. Northern New Jersey. W-9567.

Tool Engineer, 35–45, with die-making and supervisory experience, to take charge of tool and die department for manufacturer of hardware and automotive stampings. Pennsylvania. W-9569.

Assistant Superintendent, 35–45, with plant-engineering and production experience in process industry, to supervise maintenance and process operations. Good labor relations' experience essential. $6000–$8000 year. Upstate New York. W-9574.

Registered Patent Attorney with chemical or mechanical-engineering degree, for engineering-patent service. Salary open, dependent upon experience and ability. East. W-9575.

Plant Superintendent and Chief Engineer, 35–50, graduate or equivalent, with 8 years' engineering experience, two or more as maintenance engineer in plant employing at least 500 people, to operate and maintain power plant, supervise and co-ordinate all maintenance divisions, and supervise all building and ground maintenance for hospital. Physical examination. Must be able to give constructive thought and criticism to architectural plans and designs on new construction. New England. W-9584.

Industrial Engineer, under 50, with experience in ferrous foundries to supervise time studies, develop incentive plans, and co-ordinate production facilities in malleable foundry. $5000–$6000 year. Upstate New York. W-9588.

Works Manager, mechanical or electrical graduate with broad production experience, to supervise fabrication and assembly of electromechanical equipment. $15,000 year. East. W-9589.

Mechanical Engineer, with experience in Diesel-power generation, refrigeration, water works, to supervise maintenance of equipment. Some construction and installation work. $5000–$6000 year. West Indies. W-9594.

Diesel Engineer, single, thoroughly experienced, to take complete charge of Diesel plant. $3600 year, plus board and room. Hospital and medical expenses, and traveling expenses are also provided on two-year contract. Nicaragua. W-9598.

Plant Engineer, with chemical-plant experience, to co-ordinate the work in mechanical maintenance, with some designing. $4000–$5000 year. South. W-9605.

Director of Manufacturing, mechanical graduate, 35–45, with broad experience in precision-products field, to take charge of manufacture of parts, instruments, and equipment. $10,000–$12,000 year. East. W-9610.

Power Engineer, 30–45, with at least 10 years' operating experience, to direct activities of steam plants and system operations of electric plants, and study hydrology of river and drainage area. To $6500 year. New Hampshire. W-9615.

Aerodynamicists and Stress Analysts, preferably with master's degrees, with several years' experience, for development of aircraft equipment. Salaries open. Northern New Jersey. W-9624.

Designer on fuel-injection systems with Diesel-engine or hydraulic experience, familiar with intricate machinery. Permanent. $5400–$6000 year, depending upon ability and experience. Chicago. R-4226-C.

Editor Assistant, graduate mechanical engineer preferred, on paper devoted to industrial plant-production work and power plants. Should have approximately two years' industrial-plant experience as plant engineer, or equivalent. Permanent. $5000 year. R-4395.

Mechanical Engineer, high grade, to supervise design of utility steam-power stations, for large organization with headquarters in Chicago. Permanent. Approximately $7500 year. R-4401.

Engineers. (*a*) Mechanical engineer, full professor interested in research, with sufficient technical training to handle graduate courses, including supervision of research projects carried on by advanced students, as well as teaching some junior and senior courses. General fields will be heat and engineering materials. $5400–$6000 for nine and one half months. Northwest. (*b*) Editor and publicity man for the Division of Industrial Research. Approximate salary $5000 year. R-4265.

Candidates for Membership and Transfer in the A.S.M.E.

The application of each of the candidates listed below is to be voted on after October 25, 1947, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

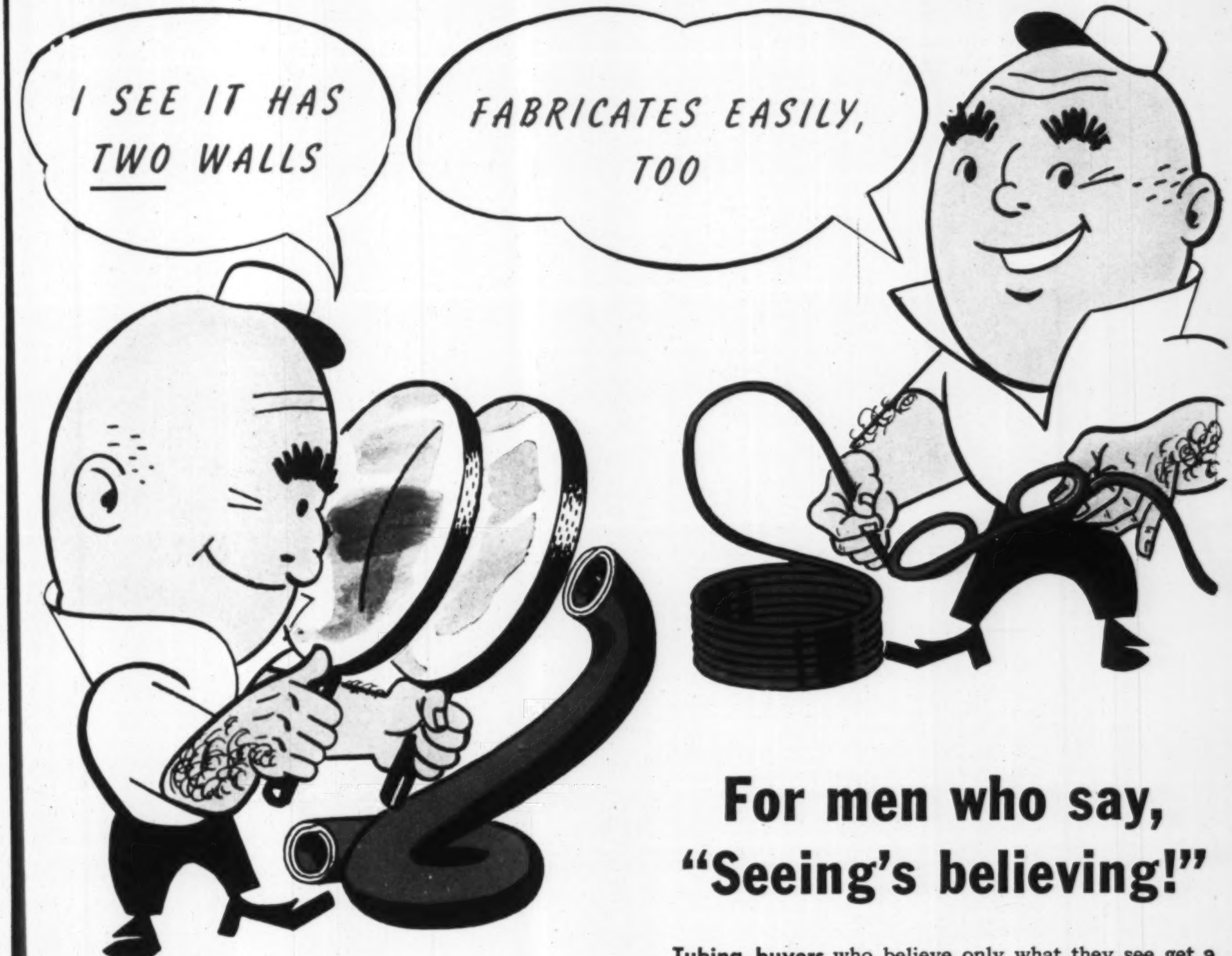
Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Fellow, Member, Associate, or Junior

Ahlm, Lloyd B., St. George, S. I., N. Y.
Anderson, C. S., Jr., Savannah, Ga.
Andreasen, I., Watkins Glen, N. Y.
Bandel, J. M., New York, N. Y.
Bellarts, Henry J., Richland, Wash. (Rt & T)
Berg, Eugene P., Evanston, Ill.
Blackstone, A. L., Jr., Columbia, S. C.
Bowman, Charles Edward, Inglewood, Calif.
Boyhan, George Edward, Palisade, N. J.
Bridge, J. Franklin, Watkins Glen, N. Y.
Brister, Paul M., Madison, N. J.
Brogdon, V. Hubert, Port Sulphur, La.
Brown, Thomas F., New York, N. Y.
Browne, Floyd Gilmore, Marion, Ohio
Cloutier, J. P., Laprairie, Quebec, Can.
Cousins, Robert M., Los Angeles, Calif.
Cyphers, Robert A., York, Pa.
Davidson, H. D., Vancouver, B. C., Can.
Dolida, Nicholas R., Brooklyn, N. Y.
Donald, A. J., New York, N. Y.
Douglass, Crede D., Jr., New Martinsville, W. Va.
Dunn, John, Tenafly, N. J.
Eger, Edward F., Chicago, Ill.
Eisele, Charles Robert, Denver, Colo.
Filiey, Charles A., Brooklyn, N. Y.
Finch, Plynn J., Richmond, Va.
Fletcher, Leslie S., New York, N. Y.
Fulton, S. D., Drexel Hill, Pa.
Gambardella, Salvatore A., Brooklyn, N. Y.
Giardina, Peter S., Philadelphia, Pa.
Gossett, Fred C., Glendale, Calif.
Green, John E., Cushing, Okla.
Hafez, A. H., New York, N. Y.
Hahn, Gordon R., Westfield, N. J. (Rt & T)
Hartwig, Frederick John, Jr., Bayonne, N. J.

(*A.S.M.E. News continued on page 888*)



For men who say, "Seeing's believing!"

Tubing buyers who believe only what they see get a hearty welcome at Bundy.

When they look at Bundyweld* Tubing, we know what they are going to learn—and we know they're going to like it.

They're going to see solid, double wall tubing of great strength—yet, it fabricates with ease.

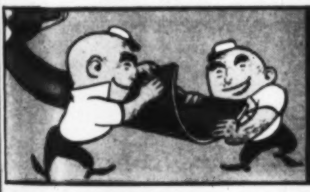
A further look will show them how Bundyweld Tubing can give greater dependability to their product at economical prices.

Look at these important advantages made possible through the patented Bundyweld process:

- **solid, double wall**
- **great resistance to vibration fatigue**
- **strength combined with ductility**
- **uniform tolerances**
- **ease of fabrication**
- **high bursting strength for pressure applications**
- **low cost**

Your tubing problems will get better answers from Bundyweld. Write today. *Bundy Tubing Company, Detroit 14, Michigan.*

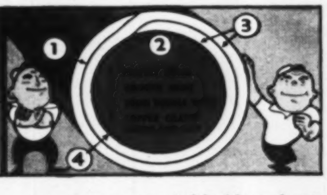
WHY BUNDYWELD IS BETTER TUBING



1 Bundyweld Steel Tubing is made by a process entirely different from that used in making other tubing. A single strip of copper-coated S.A.E. 1010 steel is continuously rolled twice laterally . . .

2 . . . into tubular form. Walls of uniform thickness and concentricity are assured by the use of close tolerance cold rolled strip. This double rolled strip passes through a furnace where the . . .

3 . . . copper coating fuses and alloys with the double steel walls. After brazing and cooling, it becomes a solid double wall steel tube, copper brazed throughout 360° of wall contact . .



4 . . . copper coated inside and out, free from scale, closely held to dimensions. Hard or annealed in standard sizes up to ⅝" O.D. Special sizes cold drawn. Also in Monel and nickel.

*REG. U.S. PAT. OFF.

BUNDY TUBING

★ ★ ENGINEERED TO ® YOUR EXPECTATIONS ★ ★

BUNDY TUBING DISTRIBUTORS AND REPRESENTATIVES:

Pacific Metals Co., Ltd.
3100 19th St.
San Francisco 10, Calif.

Standard Tube Sales Corp.
76-01 Woodhaven Blvd.
Brooklyn 27, N.Y.

Lapham-Hickey Co.
3333 W. 47th Place
Chicago 32, Illinois

Rutan & Co.
404 Architects Bldg.
Phila. 3, Pa.

Eagle Metals Co.
3628 E. Marginal Way
Seattle 4, Wash.

Alloy Metal Sales Ltd.
861 Bay St.
Toronto 5, Canada